

EXPANDED SITE INSPECTION REPORT
FOR

H.O.D. LANDFILL
ANTIOCH, ILLINOIS
U.S. EPA ID: ILD980605836
SS ID: IL2F
TDD: F05-8702-124
PAN: FILO141XB

VOLUME 1 OF 4



37

HAZARDOUS
SITE
EVALUATION
DIVISION

Field Investigation Team Zone II



CONTRACT NO.
68-01-7347

ecology and environment, inc.

International Specialists in the Environment

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SEPTEMBER 22, 1989



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1. INTRODUCTION

H.O.D. Landfill is approximately 50 acres in area and is located on an 80-acre site in Antioch, Illinois. The landfill is currently inactive and is being closed in accordance with Illinois Environmental Protection Agency (IEPA) regulations. The landfill was owned and operated successively by three distinct companies from 1963 to 1983. The site property is currently owned by Waste Management of Illinois, Inc. (WMII), and the village of Antioch. Solvents, heavy metals, and cutting and hydraulic oils have possibly been disposed of at the landfill, along with municipal waste during its operation according to a United States Environmental Protection Agency (U.S. EPA) Hazardous Waste Site Notification form. The form was submitted to U.S. EPA as required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act in June 1981 by WMII, which was the owner and operator of the site at the time (WMII 1981).

A preliminary assessment (PA) (U.S. EPA Form 2070-12) was prepared for the site by Ecology and Environment, Inc. (E & E), Field Investigation Team (FIT). The PA is dated February 11, 1983. U.S. EPA then tasked FIT to conduct a site inspection (SI) (U.S. EPA Form 2070-13) of the site on July 10, 1984. FIT subsequently prepared and submitted to U.S. EPA a Hazard Ranking System (HRS) model score for the site in April 1985.

On September 18, 1985, U.S. EPA proposed that the H.O.D. Landfill site be placed on the National Priorities List (NPL) as an uncontrolled hazardous waste site. The proposal to list the site on the NPL was based, in part, upon an observed release of contaminants from the site

to groundwater at the site detected during the SI. The site received an HRS model score of 52.02. Following a public comment period, U.S. EPA tasked FIT on November 25, 1986, to conduct an Expanded Site Inspection (ESI) of the H.O.D. Landfill site.

The objective of this ESI is to provide information required by U.S. EPA to respond to public comments received when the site was proposed for the NPL. To meet this objective, specific goals of the ESI were established, including the following:

- Determining the extent of subsurface soil contamination in the vicinity of the landfill;
- Evaluating physical characteristics of subsurface soils in the site area;
- Defining the stratigraphy and characterizing groundwater flow patterns in the site area;
- Determining the effectiveness of a potentially present confining unit; and
- Determining whether groundwater in the area of the site is contaminated.

The scope of work to accomplish these goals consisted of the following tasks.

- Preparation for the site investigation, including the preparation of a work plan and submittal of the work plan to U.S. EPA for approval, a site background information search, and an assessment of the site to determine health and safety requirements for conducting on-site activities.
- A site investigation, including a geophysical investigation; a hydrogeological investigation that included the installation of groundwater monitoring wells and streambed

well points, tests for aquifer interconnection and horizontal hydraulic conductivities; the collection of soil samples for chemical and physical analysis; and the collection of groundwater samples for chemical analysis.

- Preparation of a report presenting site background information, descriptions of field investigation procedures, results and discussions of the field investigation, and conclusions.

2. SITE BACKGROUND

2.1 SITE DESCRIPTION

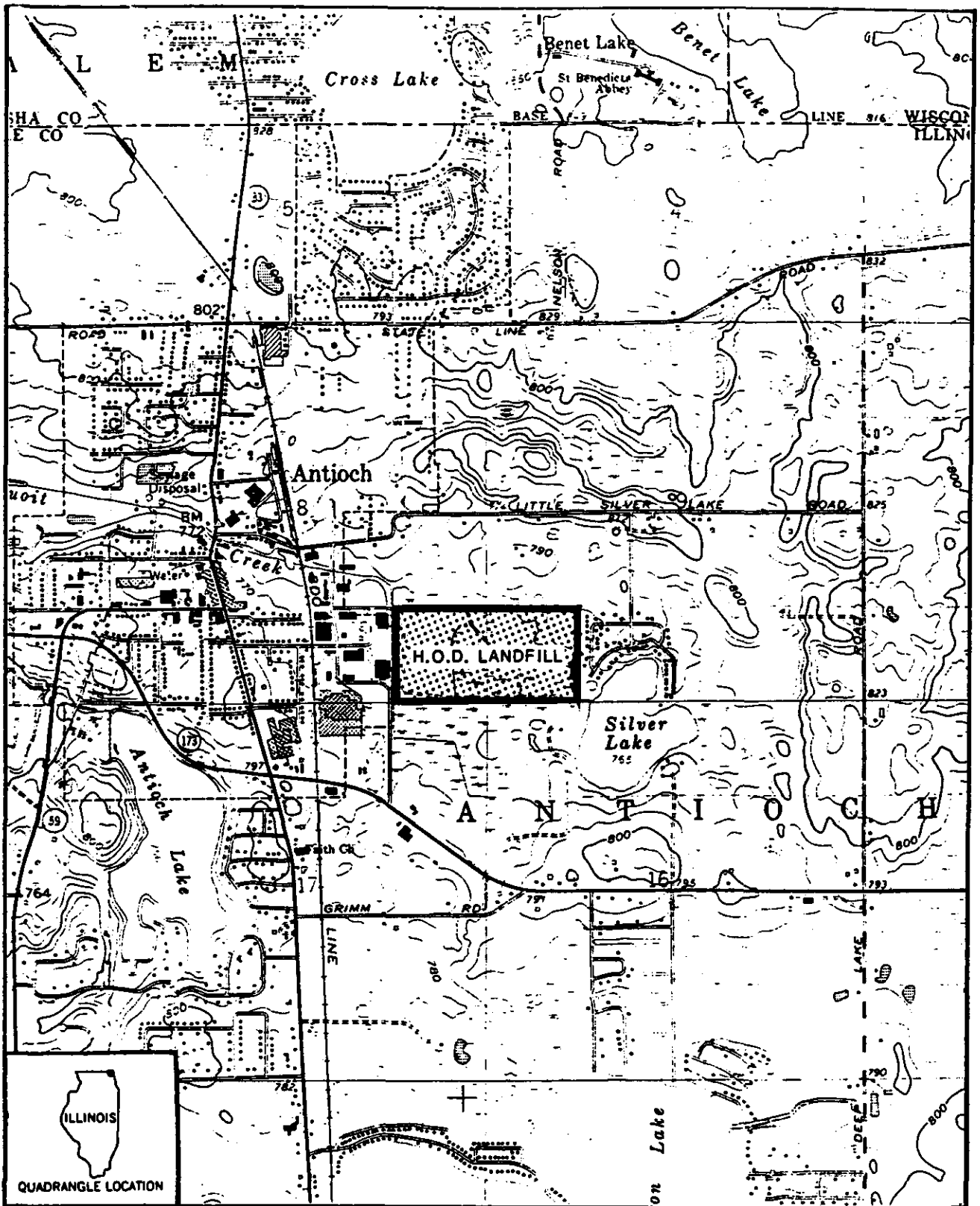
The H.O.D. Landfill site is located within the eastern boundary of the village of Antioch in Lake County, Illinois (T.46N., R.10E., sections 8 and 9) (see Figure 2-1). The site is bordered on the south and west by Sequoit Creek; a large wetland is located to the south; the Silver Lake Park residential subdivision is located to the east of the site (Silver Lake is located approximately 200 feet southeast of the site); agricultural land, scattered residential areas, and undeveloped land is to the north; and an area of light industry and an alleged former dump (Morris 1963) is located to the west (see Figure 2-2).

2.2 SITE HISTORY

The following site history is based on information obtained from a responsible party search draft final report prepared by Versar, Inc. (Versar 1986), for the U.S. EPA Office of Waste Programs Enforcement.

The H.O.D. Landfill site has been owned and operated successively by three distinct companies from 1963: Cunningham Cartage, Inc.; H.O.D. Disposal, Inc.; and WMII and its subsidiaries.

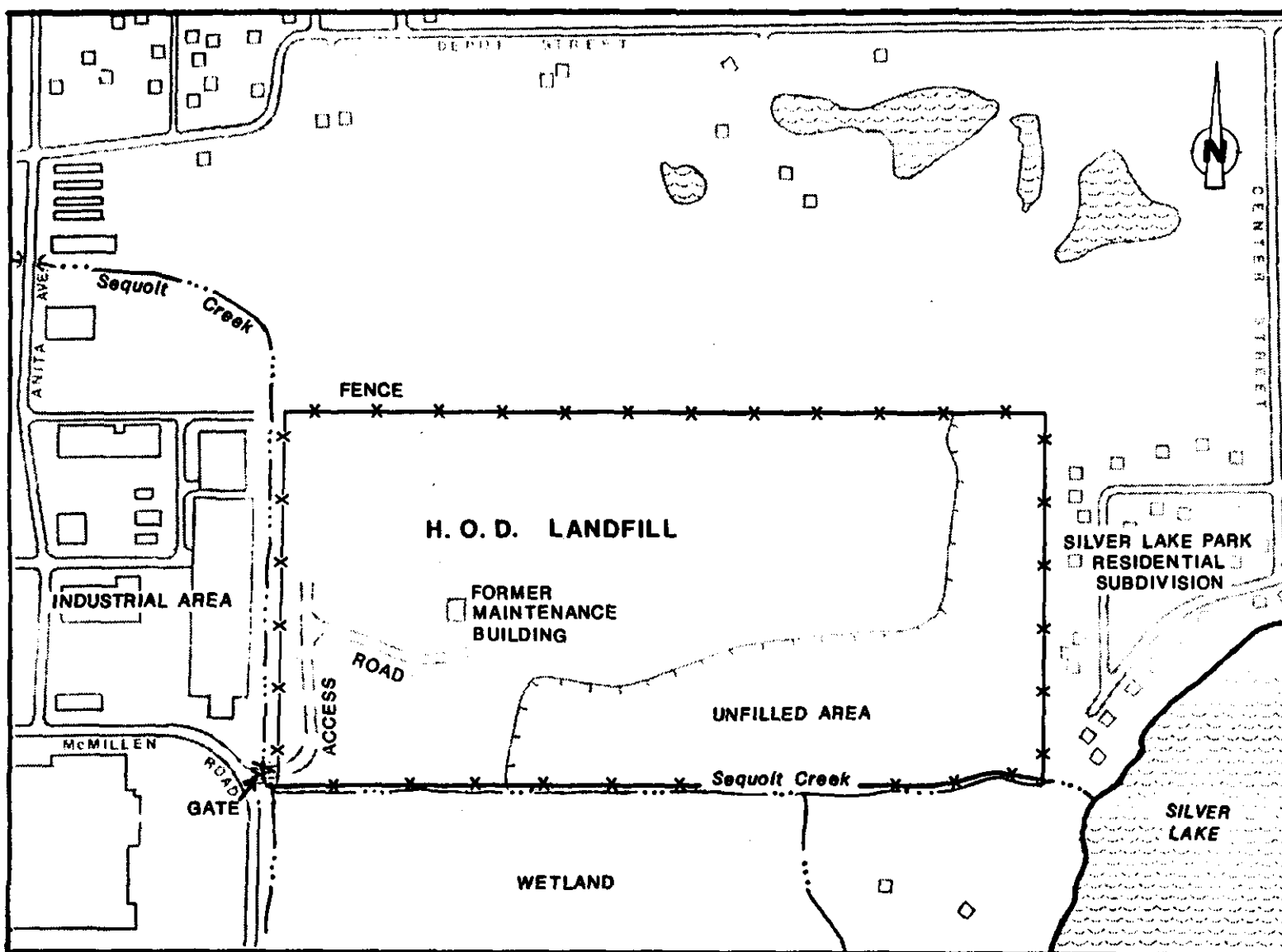
Murrill Cunningham, owner, operator, and president of Cunningham Cartage, Inc., operated a 20-acre sanitary landfill on a parcel of land of what is now part of the H.O.D. Landfill site. Cunningham was granted permits by the Lake County Health Department (LCHD) to operate a sanitary landfill beginning in October 1963. During his ownership and operation of the landfill, Cunningham applied to Lake County for a permit to



SOURCE: Ecology and Environment, Inc. 1989; BASE MAP: USGS, Antioch, IL Quadrangle, 7.5 Minute Series, 1960.



FIGURE 2-1 SITE LOCATION



SOURCE: Ecology and Environment, Inc. 1989.

SCALE
0 500 1000 1500 2000 2500 FEET

FIGURE 2-2 SITE FEATURES

expand his landfill operations, but his permit request was denied because the area of the requested expansion was not zoned to accommodate a landfill.

The site property was then purchased in August 1965 by John Horak and Charles Dishinger, who continued to operate the site under the name H.O.D. Disposal, Inc. In October 1965, H.O.D. Disposal, Inc., applied to LCHD to expand the landfill to 80 acres in area. The proposed 80-acre landfill included the 20-acre landfill originally owned by Cunningham and an adjacent 60 acres to the east of the landfill. The expansion plans were denied by LCHD because the 60 acres of land proposed to be used for the expansion was not zoned to accommodate a sanitary landfill.

Beginning in 1971, all solid waste disposal facilities in Illinois were required by state law to obtain operator permits from IEPA. H.O.D. Disposal, Inc., submitted a permit application to IEPA for its 20-acre landfill. The permit application was denied because sufficient information was not supplied. From 1971 until mid-1973, H.O.D. Disposal, Inc., operated its 20-acre landfill without an IEPA operator's permit.

In December 1972, the 20-acre land parcel on which H.O.D. Landfill, Inc., operated was conveyed to C.C.D. Disposal, Inc. Also in December 1972, C.C.D. Disposal, Inc., purchased the adjacent 60 acres of land to the east of H.O.D. Landfill. In June 1973, WMII merged with H.O.D. Disposal, Inc., and C.C.D. Disposal, Inc., gaining ownership of the H.O.D. Landfill site; WMII continued operations at the site. H.O.D. Disposal, Inc., and C.C.D. Disposal, Inc., became subsidiaries of WMII through the merger. WMII and its subsidiaries continued operating the landfill without an IEPA operator's permit.

In November 1973, C.C.D. Disposal, Inc., a subsidiary of WMII, filed a petition for a zoning change to operate an 80-acre landfill at the site (the 80-acre landfill consisted of the 20-acre H.O.D. Landfill and the 60-acre parcel of land purchased by C.C.D. Disposal, Inc.). The zoning change was subsequently approved and became effective on July 17, 1974. In June 1974, WMII applied to LCHD and IEPA for permits to operate an 80-acre solid waste disposal facility at the site. The LCHD permit was granted on July 30, 1974. The IEPA operator's permit was not received by WMII until July 1979. Until the time the IEPA operator's permit was received, WMII and its subsidiaries operated the 20-acre

landfill without a state permit. When the IEPA operating permit was granted for the 80-acre solid waste disposal facility, landfilling operations were expanded onto portions of the adjacent 60-acre property.

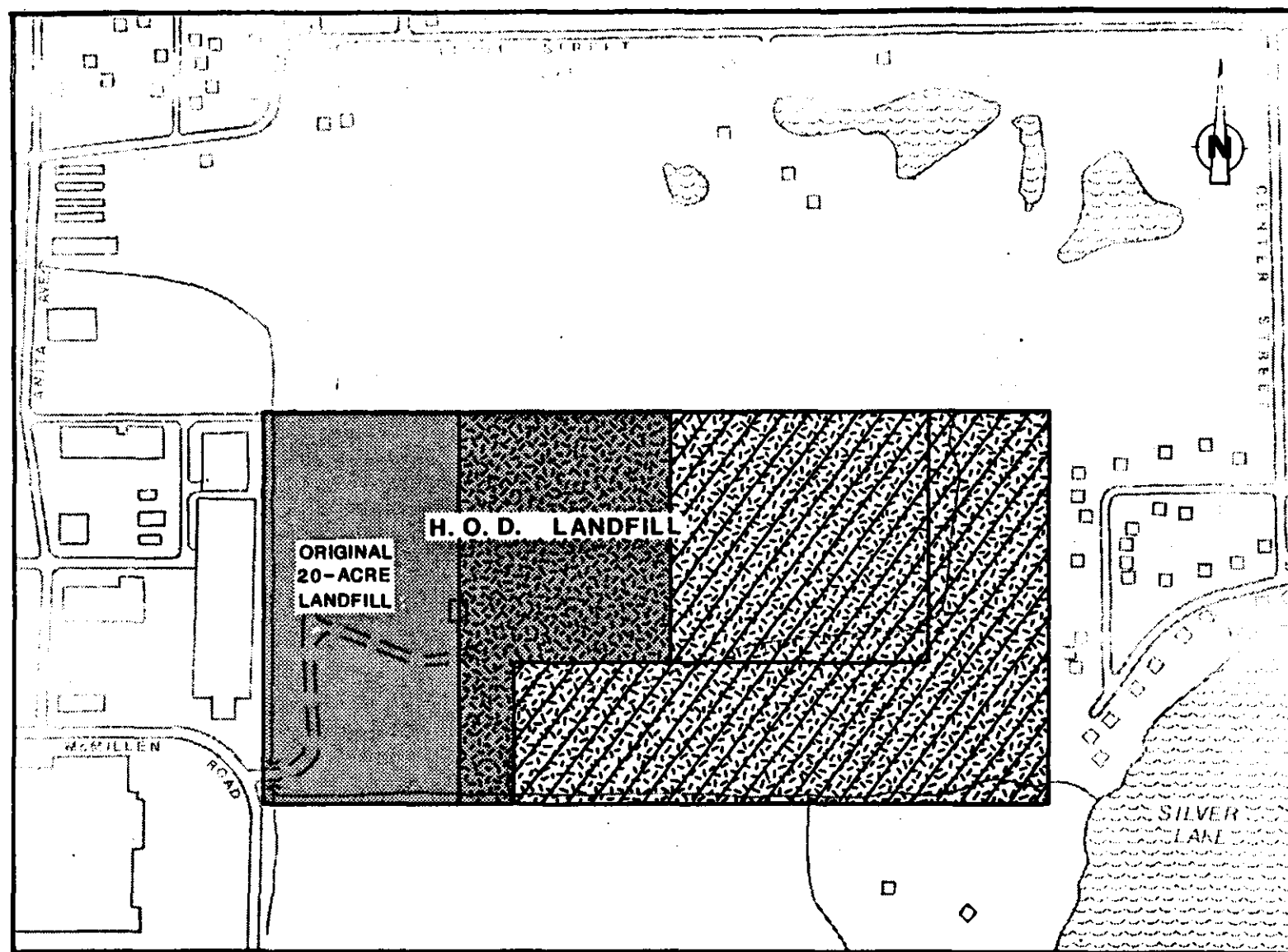
The 60-acre property onto which the landfill was expanded consists of three parcels (the original 20-acre landfill is a separate parcel of land). All of the parcels became the property of WMII upon its merger with C.C.D. Disposal, Inc., and H.O.D. Disposal, Inc., in June 1973 (see Figure 2-3). In January 1975, WMII donated two parcels of the 60-acre expansion property to the village of Antioch (see Figure 2-3), but retained rights to operate a landfill on each parcel for designated periods of time.

Between July 1975 and the closing of the landfill in 1984, various supplemental permits were granted by IEPA to WMII to modify development and operational permits for the site. In 1982, WMII again applied to IEPA to expand the H.O.D. Landfill site onto land located north of, and adjacent to, the 80-acre site. The request was denied by IEPA and also by LCHD. WMII appealed the ruling through the judicial system to the Illinois Supreme Court; the court upheld the IEPA decision to deny expansion. By late 1983, H.O.D. Landfill (the 80-acre site) was filled to capacity. WMII exhausted its options for expansion and ceased accepting wastes for disposal at the site in 1984.

A lawsuit has been filed by the village of Antioch against WMII alleging breach of contract, creating a nuisance, and wrongful use of land. The lawsuit is currently pending.

During operation of H.O.D. Landfill, permits had been issued by IEPA for the disposal of municipal waste and a variety of industrial wastes at the site. These industrial wastes included, but were not limited to, emulsion polymerization waste containing phenol, lead, and zinc; baghouse dust and grinding sludge containing chromium, cyanide, and nickel; waste filter cake and latex sludge containing cyanide, phenol, and zinc; and aluminum dross containing lead, arsenic, and chromium (IEPA 1980, 1980a, 1981, 1981a, 1982).

Although the total amount of waste accepted at the site is unknown, a minimum of 86,000 drum equivalents of waste containing hazardous constituents are known to have been disposed of in the landfill (IEPA 1985). In addition to the IEPA-permitted wastes, several other types of



SOURCE: Ecology and Environment, Inc. 1989.

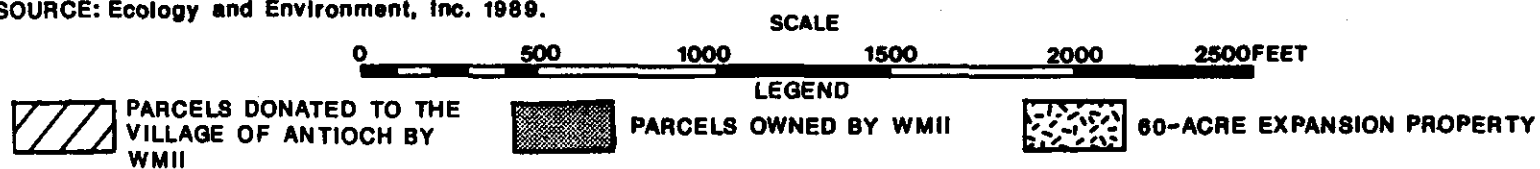


FIGURE 2-3 LAND PARCELS OF THE H.O.D. LANDFILL SITE

wastes are alleged to have been dumped at the site illegally, including caustic wastes, kerosene, cyanide-bearing wastes, and polychlorinated biphenyls (PCBs) (Versar 1986).

2.3 GEOGRAPHY

2.3.1 Physiography

Lake County is situated in the Wheaton morainal country within the Great Lakes section of the Central Lowland Province. In general, the topography of the area is characterized by gentle slopes with poorly defined surface drainage patterns, depressions, and wetlands. The maximum relief in the county is 340 feet.

Approximately two-thirds of the surface drainage in Lake County is directed toward the Des Plaines River, located approximately 5 miles east of the site. The remaining one-third of the surface drainage is directed either east toward Lake Michigan or west toward the Fox River (United States Department of Agriculture [USDA] 1970). Surface drainage from the site is toward the Fox River, located approximately 5 miles to the west.

The topography in the vicinity of the site is generally flat. The most prominent topographic feature in the area is the landfill. The maximum relief of the site is approximately 40 feet. The highest elevation on-site occurs approximately 500 feet northeast of an on-site former maintenance building located in the eastern-central portion of the site (see Figure 2-2), and the lowest elevation is along Sequoit Creek at the northwestern corner of the site (WMII 1988).

Based on a review of aerial photographs of the site area, Sequoit Creek originally flowed northwest from Silver Lake to a point that is now the approximate center of the northern boundary of the site, where it then flowed west toward the village of Antioch. However, sometime between 1961 and 1967, Sequoit Creek was rerouted to flow west from Silver Lake along what is currently the southern boundary of the H.O.D. Landfill site property. At the southwestern corner of the landfill, the creek was routed to flow north along the western boundary of the landfill property. Approximately 250 feet north of the northwestern corner of the landfill, the creek resumes its original route and flows west approximately 2 miles before discharging into Lake Marie. Water entering

Lake Marie eventually discharges to the Fox River (United States Geological Survey [USGS] 1960). According to aerial photographs and a USGS (1960) topographic map of the area of the site, prior to landfill development and the rerouting of Sequoit Creek, the eastern portion of the site property had been a wetland.

2.3.2 Climate

Lake County is situated within a continental climatic belt where frequent variations in temperature, humidity, and wind direction are common. Temperature varies from an average daily minimum of 15° Fahrenheit in January to an average daily maximum of 83° Fahrenheit in July. The average annual precipitation is 32.5 inches. The wettest months are April through September (USDA 1970).

2.3.3. Land Use and Demography

Land use in Lake County is primarily agricultural, although urbanization and recreational use of the area is increasing. Agricultural acreage is primarily used for the planting of corn; a lesser acreage is used for dairy and hay production (USDA 1970).

Urbanization in Lake County has been occurring along the shore of Lake Michigan, in southern portions of the county, and to the east of the Des Plaines River. The population of Lake County in 1980 was 440,387; the village of Antioch accounted for 4,419 persons of this total (U.S. Bureau of the Census 1982).

2.4 GEOLOGY

2.4.1 Geologic Setting

Lake County is located along the northeastern flank of a northwest/southeast trending structural high known as the Kankakee Arch. The bedrock surface of northeastern Illinois varies in depth from 90 to 325 feet below the ground surface (Woller and Gibb 1976). The bedrock surface dips gradually toward the east and exhibits an uneven surface as the result of pre-glacial erosion.

The bedrock surface is completely overlain by thick sequences of glacial deposits. These unconsolidated deposits exhibit evidence of multiple episodes of glacial advances and retreats of late Wisconsinan

glaciation (see Figure 2-4 for a generalized stratigraphy of the unconsolidated deposits in northern Lake County). The surface topography of the area is characterized by a series of parallel, onlapping moraines and intermorainal valleys. This morainal complex is composed of deposits of the Wadsworth Till Member of the Wedron Formation (see Figure 2-5). Deposition of the Wadsworth Till represents the last advance of the Joliet Sublobe of the Lake Michigan Lobe (Willman and Frye 1970). The moraines decrease in age toward the east and are onlapped by lacustrine deposits of the Lake Chicago plain (see Figure 2-6).

2.4.2 Stratigraphy

Throughout most of Lake County, the uppermost unit of the bedrock sequence consists of Silurian dolomite of the Niagaran Series. This dolomite unconformably overlies Upper Ordovician, Maquoketa Group shales, and ranges in thickness from 0 to 270 feet. The Maquoketa Group is the uppermost bedrock unit in small isolated areas along the western portion of the county. The Maquoketa Group ranges in thickness from 100 to 240 feet and consists primarily of thick non-water-bearing shales (see Figure 2-7 for a generalized column of the bedrock stratigraphy in northeastern Illinois).

Woodfordian-age glacial deposits of a thickness of 90 to 325 feet (Woller and Gibb 1976) overlie Ordo-Silurian strata in northeastern Illinois. The Wadsworth Till Member of the Wedron Formation encompasses the majority of unconsolidated deposits in Lake County (see Figure 2-8). The Wadsworth Till ranges in thickness from 5 to 165 feet in Illinois and 5 to 150 feet in Lake County.

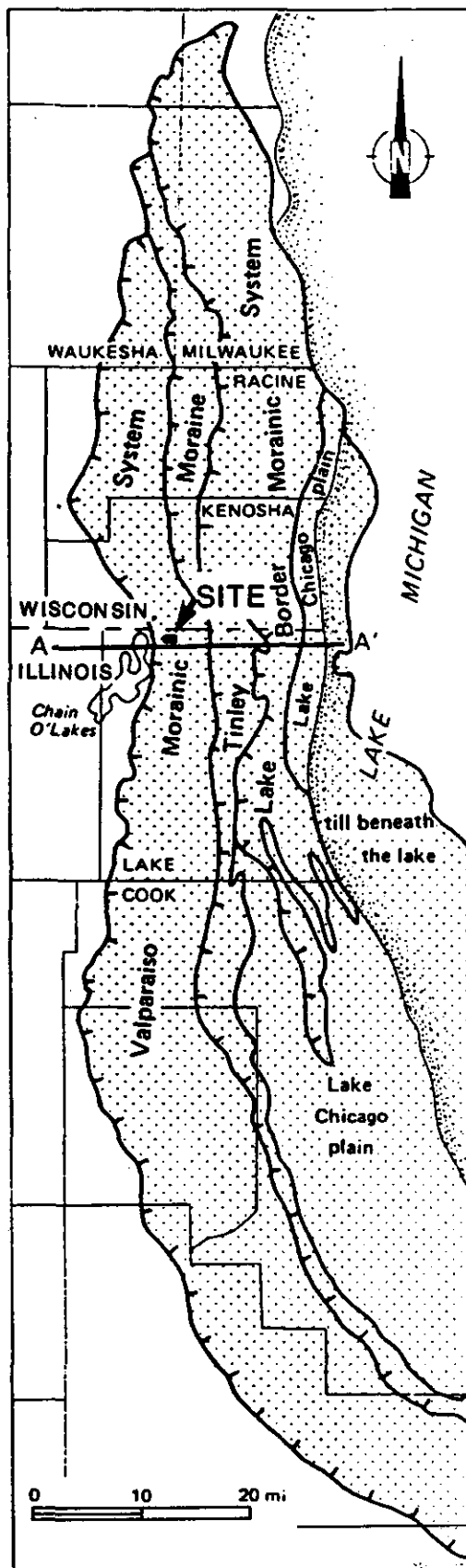
Outwash and till deposits of the Haeger Till Member occur locally along the western edge of Lake County and westward into McHenry County. Lake County well log data indicates that the Wadsworth Till does not overlie the Haeger Till (Hansel 1983). However, Wadsworth Till overlies Haeger Till in Wisconsin.

Underlying the Wadsworth Till in Lake County is a reddish-gray, silty till with an illite content averaging 70% (Hansel 1983). This till directly overlies bedrock and is interbedded with localized outwash and lake deposits. The reddish-gray till is Woodfordian in age, but an accurate correlation with older Wedron deposits has not been documented.

Time Stratigraphy			Illinois Rock Stratigraphy		Wisconsin Rock Stratigraphy	
Quaternary System	Pleistocene Series	Holocene Stage	Lake Michigan Fm. un-named fm.		Kewaunee Formation Oak Creek Fm. New Berlin Fm. Zenda Fm.	
		Valderan/Greatlakean Substage		Two Rivers Till Mbr.		Two Rivers Mbr.
		Twocreekan Substage				
		Woodfordian Substage	Wedron Formation			Valders Mbr.
				Manitowoc Till Mbr.		Haven Mbr.
				Shorewood Till Mbr.		Ozaukee Mbr.
				Wadsworth Till Mbr.		present?
				Haeger Till Mbr.		
				Yorkville Till Mbr.		not represented
				Malden Till Mbr.		
				Tiskilwa Till Mbr.		Tiskilwa Mbr.
		Farmdalian Substage				

SOURCE: Hansel 1983.

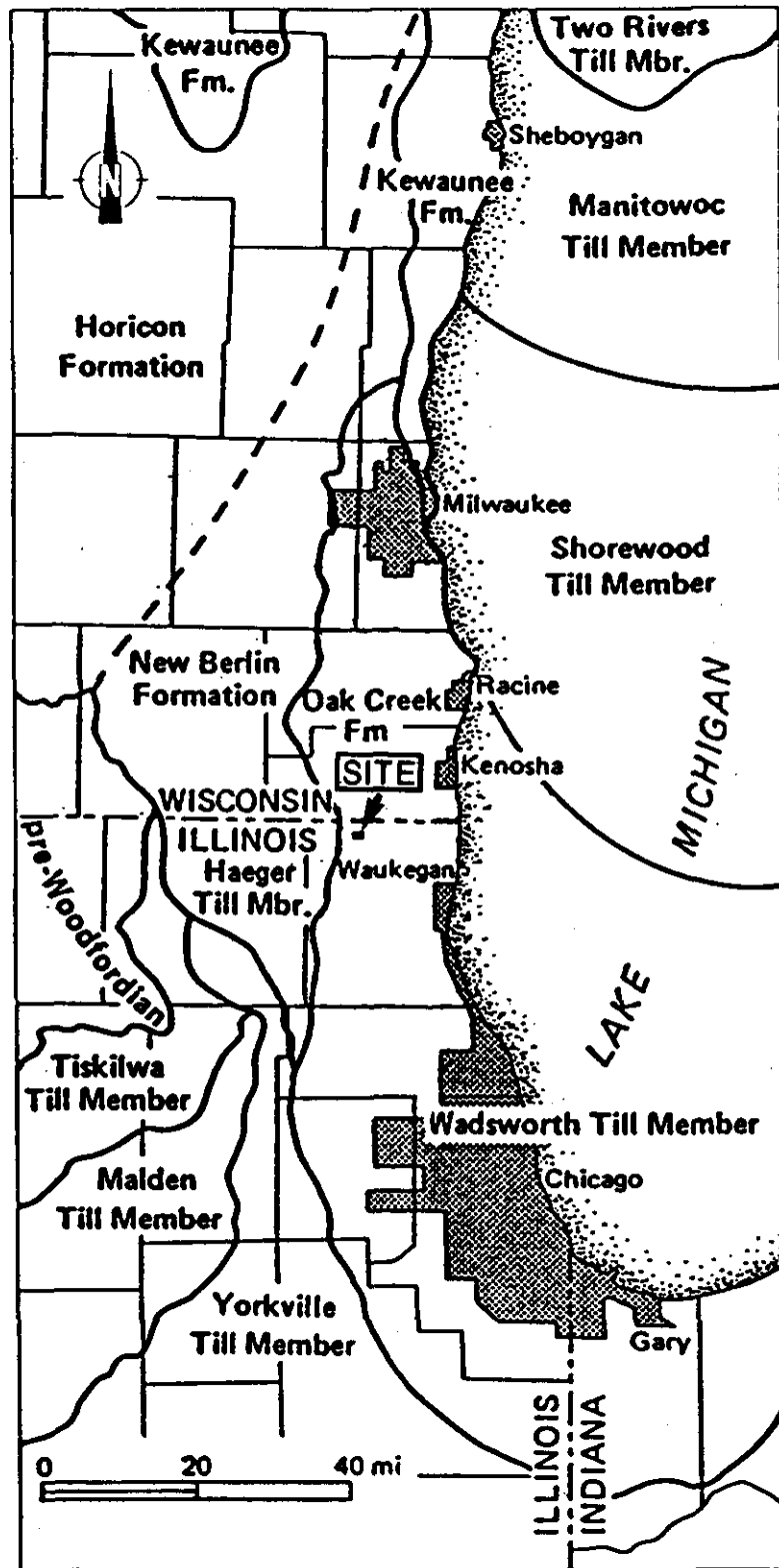
FIGURE 2-4 STRATIGRAPHY OF UNCONSOLIDATED DEPOSITS IN NORTHERN LAKE COUNTY



SOURCE: Hansel 1983

NOTE: See Figure 2-8 for cross section of A-A'.

FIGURE 2-5 LOCAL DISTRIBUTION OF THE WADSWORTH TILL MEMBER



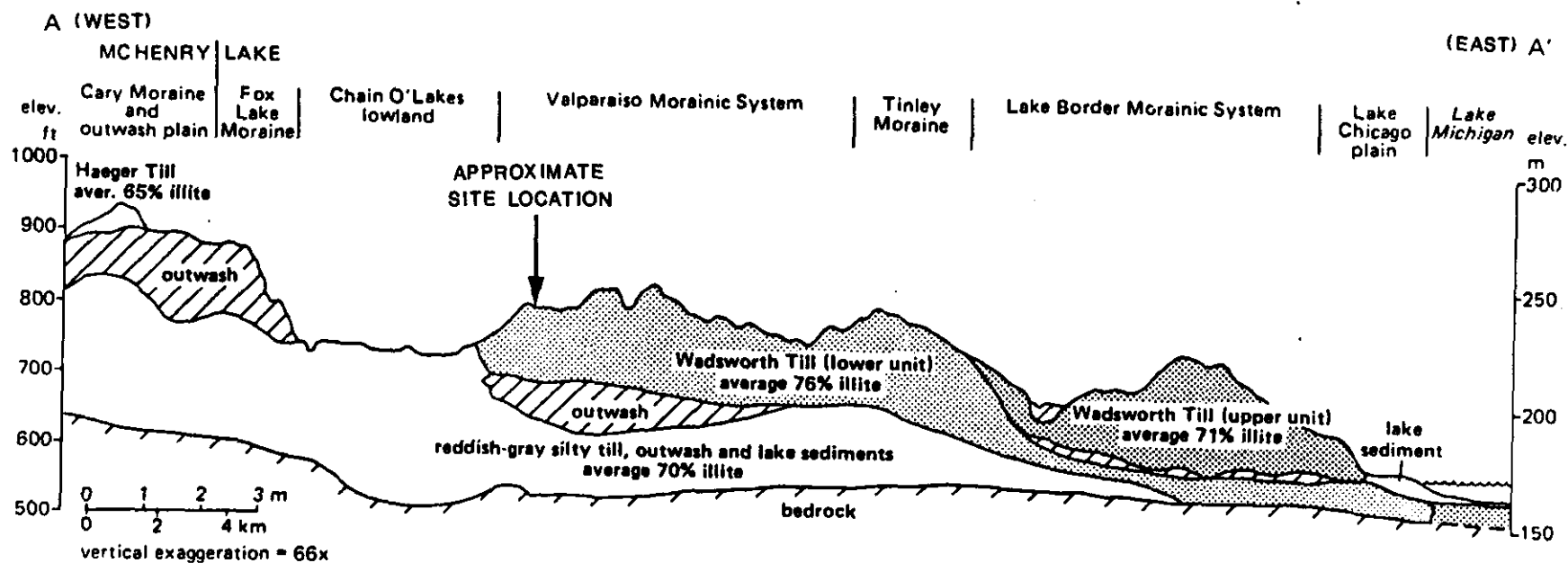
SOURCE: Hansel 1983.

FIGURE 2-6 SURFICIAL TILL UNITS

SYSTEM	SERIES	GROUP OR FORMATION	AQUIFER	LOG	THICKNESS (FT)	DESCRIPTION
QUATERNARY	PLEISTOCENE		Sands and Gravels		90-325	Unconsolidated glacial deposits-pebbly clay (till), silt, sand and gravel Alluvial silts and sands along streams
					Fissure Fillings	Shale, sandy, brown to black
SILURIAN	NIAGARAN	Racine	Silurian		0-180	Dolomite, very pure to argillaceous, silty, cherty; reefs in upper part
		Sugar Run				Dolomite, slightly argillaceous and silty
		Joliet				Dolomite, very pure to shaly and shale, dolomitic; white, light gray, green, pink, maroon
	ALEXANDRIAN	Kankakee			0-90	Dolomite, pure top 1'-2', thin green shale partings, base glauconitic
		Elwood				Dolomite, slightly argillaceous, abundant layered white chert
		Wilhelmi				Dolomite, gray, argillaceous and becomes dolomitic shale at base
ORDOVICIAN	CINCINNATIAN	Maquoketa	Shallow dolomite aquifer		100-240	Shale, red; oolites Shale, silty, dolomitic, greenish gray, weak (Upper unit) Dolomite and limestone, white, light gray, interbedded shale (Middle unit) Shale, dolomitic, brown, gray (Lower unit)
	CHAMPLAINIAN	Galena			270-335	Dolomite, and/or limestone, cherty (Lower part) Dolomite, shale partings, speckled
		Platteville				Dolomite and/or limestone, cherty, sandy at base
		Glenwood			165-300	Sandstone, fine and coarse grained; little dolomite; shale at top
		St. Peter				Sandstone, fine to medium grained; locally cherty red shale at base
CAMBRIAN	CROIXAN	Eminence	Cambrian-Ordovician aquifer		0-100	Dolomite, light colored, sandy, thin sandstones
		Potosi				Dolomite, fine-grained, gray to brown, drusy quartz
		Franconia			40-80	Dolomite, sandstone and shale, glauconitic, green to red, micaceous
		Ironton			100-190	Sandstone, fine to coarse grained, well sorted; upper part dolomitic
		Galesville				
		Eau Claire			385-475	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic
		Elmhurst Member			1200-2000	Sandstone, coarse grained, white, red in lower half; lenses of shale and siltstone, red, micaceous
		Mt. Simon				
PRE-CAMBRIAN						Granitic rocks

SOURCE: Weller and Gibb 1976.

FIGURE 2-7 GENERALIZED COLUMN OF THE BEDROCK STRATIGRAPHY OF NORTHEASTERN ILLINOIS



SOURCE: Hansel 1983.

NOTE: See Figure 2-5 for location of cross section.

FIGURE 2-8 TYPICAL CROSS SECTION OF UNCONSOLIDATED DEPOSITS IN NORTHEASTERN ILLINOIS

No other till units overlie the Wadsworth Till in Lake County (Hansel 1983). The Wadsworth Till is a gray, silty, clay-rich till that contains a relatively low percentage of gravel clasts greater than 2mm in size. It is also characterized by a relatively high illite content of 76% (Hansel 1983). The sand content of the Wadsworth Till generally increases from east to west and is usually distinguishable from the older Yorkville Till. The Yorkville Till is generally absent in Lake County but possibly underlies the Wadsworth Till in northern Cook County (Hansel 1983).

Outwash deposits of the Batavia and Wasco Members of the Henry Formation are spatially localized throughout Lake County; isolated deposits of the Grayslake Peat are also common (Lineback 1979).

2.4.3 Groundwater Occurrence and Use

Groundwater resources in Lake County are present in four aquifer systems. These systems include sand and gravel deposits of glacial origin, a shallow bedrock sequence of Silurian-aged dolomites, deeper bedrock sequences of Cambro-Ordovician sandstones and dolomites, and a basal Cambrian sandstone sequence. Of the bedrock aquifers, the Silurian dolomite is the primary source of groundwater in the county. However, the sand and gravel aquifers provide only slightly less groundwater than the bedrock aquifers.

Surficial sand and gravel deposits are fairly extensive throughout Lake County. Confined and unconfined deposits of sand and gravel exist throughout the county; the majority of the confined units are located in the western portion of the county. Recharge to the sand and gravel aquifers is derived locally from precipitation (Illinois State Water Survey 1976). Many residential wells in the Antioch area, and the village of Antioch's public water supply system, obtain groundwater from glacially derived sand and gravel deposits.

The shallow bedrock aquifer (the Silurian dolomite) is tapped by many public water utility systems in the county. The yield capacity of this aquifer varies depending upon fracture density and aquifer thickness (Woller and Gibb 1976). The aquifer is recharged by the downward migration of water from the overlying glacial deposits. Recharge and yield is enhanced in areas where sand and gravel deposits are in contact

with the bedrock surface. The Silurian dolomite aquifer is separated from the deeper aquifer systems by the relatively impermeable Maquoketa Group.

The deep bedrock sequences, consisting of a series of interconnected sandstones and dolomites ranging in age from Lower Ordovician to Cambrian, are referred to as the Midwest Bedrock Aquigroup (Sasman et al. 1986) (see Figure 2-6 for the sequence of aquifers in this group).

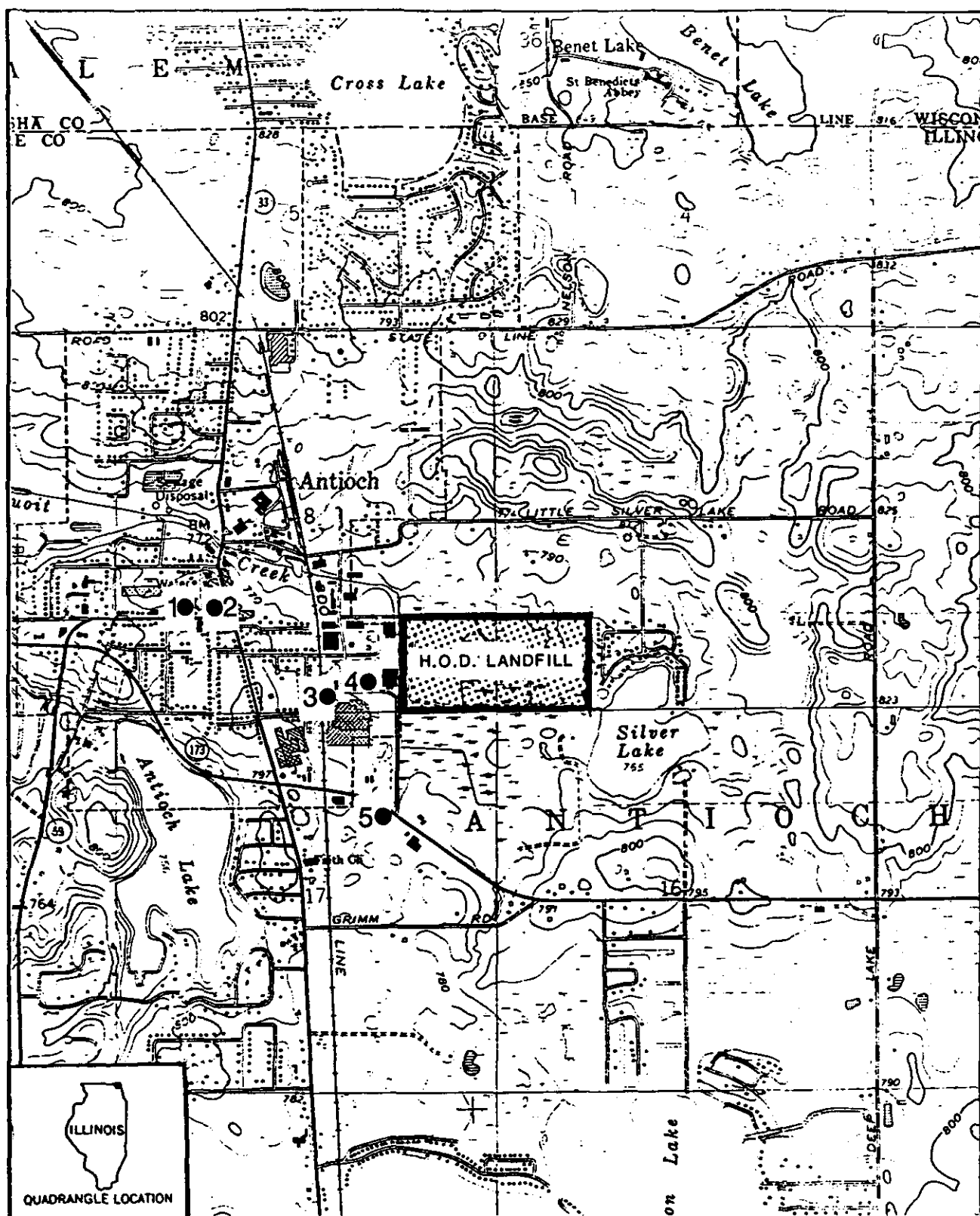
The deepest aquifer in Lake County is the Elmhurst Mount Simon aquifer. The overlying Eau Claire Formation provides an adequate confining layer for this Basal Cambrian aquifer.

The village of Antioch obtains its water from five wells screened in a sand and gravel aquifer situated within the Wadsworth Till. This sand and gravel unit begins at depths ranging from 70 to 140 feet. The thickness of this unit is estimated to be at least 185 feet in the immediate Antioch area (see Figure 2-9 for village of Antioch municipal well locations). Under normal operating conditions, the village wells are automatically activated in an alternating cycle when the water pressure from aboveground water storage tanks drops below a designated level; wells 1 and 4 operate simultaneously, as do wells 2 and 3; well 5, when activated, pumps alone. These wells are finished at depths ranging from 141 to 225 feet. Wells 3, 4, and 5 are rated at 500, 650, and 750 gallons per minute (gpm), respectively. Wells 1 and 2 yield 150 and 250 gpm, respectively.

According to well logs of the area of the site, most privately owned wells in the vicinity of the site are screened in the same glacial drift aquifer used by the village of Antioch. These wells are finished at depths ranging from approximately 85 to 250 feet. Bedrock wells in the area are finished in the Silurian dolomite aquifer. The bedrock wells range in depth from approximately 215 to 330 feet. (Well logs of the area of the site are provided in Appendix B.)

2.5 PREVIOUS INVESTIGATIONS

Investigations at the H.O.D. Landfill site have included soil investigations, a hydrogeologic assessment, and a series of groundwater quality monitoring studies on-site and in the vicinity of the site.



SOURCE: Ecology and Environment, Inc. 1989; BASE MAP: USGS, Antioch, IL Quadrangle, 7.5 Minute Series, 1960.



FIGURE 2-9 VILLAGE OF ANTIOCH MUNICIPAL WELL LOCATIONS

Testing Service Corporation (TSC) conducted a soils investigation at the site in 1973 to assess the soil conditions for the proposed expansion of the H.O.D. Landfill site and the construction of an on-site maintenance building. During the investigation, 25 borings were conducted. Deposits of saturated sand located near the southern boundary of the site were identified. However, the extent of the sand deposits was not defined (TSC 1973).

In May 1974, TSC installed six groundwater monitoring wells (WMII wells) on the H.O.D. Landfill property. A cluster of two wells, G11S/G11D, is located near the northwestern corner of the site; one well, G102, is located near the southwestern corner of the site; one well, G103, was located near the southcentral area of the site (this well was ultimately decommissioned and a replacement well [R103] was installed in close proximity to well G103); and another cluster of two wells, G14S/G14D, is located near the southeastern corner of the site (see Figure 2-10 for locations of the TSC-installed monitoring wells). (Logs of the TSC-installed wells are provided in Appendix B.)

In February 1981, TSC drilled an additional 26 soil borings at the H.O.D. Landfill. The borings were drilled at locations directed by a representative of Waste Management, Incorporated (WMI). Logs of the borings were submitted to WMI by TSC with a letter dated February 25, 1981 (TSC 1981). (It is not known whether a summary of the borings or boring location maps were included.)

A computer-generated "Trend Analysis Report" summarizing the chemical analysis of samples collected from monitoring wells at the H.O.D. Landfill site was prepared by IEPA and attached to a letter dated May 7, 1982, from John D. Student of IEPA to Jim Vankerkloot of the Illinois Attorney General's office. The trend analysis report summarized the analytical data of samples collected between November 1974 and December 1981 from six on-site monitoring wells. Of the parameters tested for, iron, residue on evaporation, and zinc were consistently detected at relatively high concentrations (IEPA 1982a).

At the request of U.S. EPA, a PA was completed on February 11, 1983, by FIT as part of U.S. EPA's PA program. Data gaps identified at the time of the PA included determinations of waste quantity and whether groundwater or surface water at the site was contaminated.

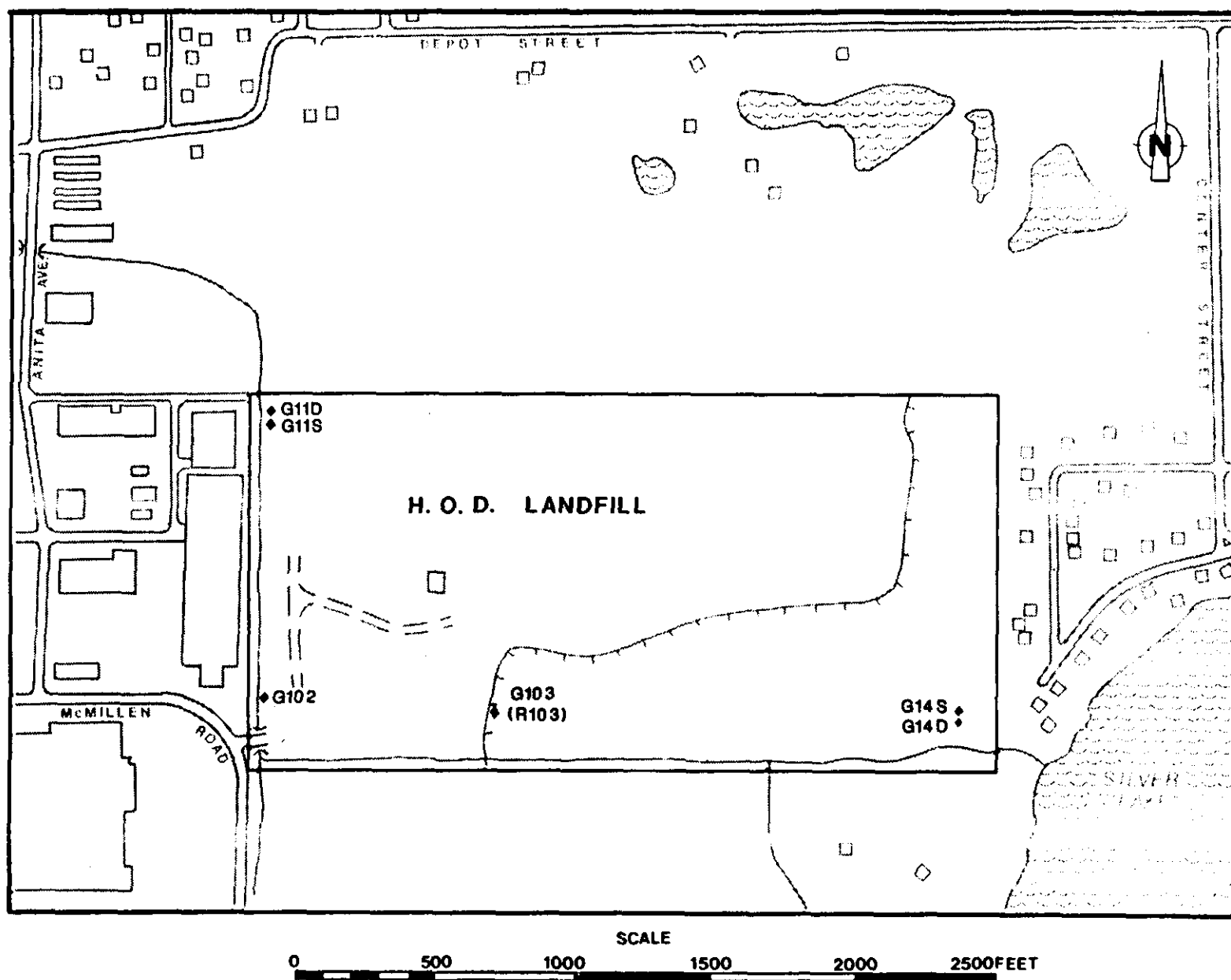


FIGURE 2-10 LOCATIONS OF ON-SITE MONITORING WELLS INSTALLED PREVIOUS TO THE FIT ESI

As a result of the data gaps cited in the PA, U.S. EPA requested that an SI be conducted at the site. The SI was conducted on July 10, 1984, by FIT. During this inspection, groundwater samples were collected from on-site monitoring wells. Chemical analysis of the groundwater samples revealed the presence of elevated concentrations of zinc, lead, and cadmium. Chemical analysis of surface water samples collected from Sequoit Creek during the SI did not reveal contaminants.

In April 1985, at the request of U.S. EPA, FIT prepared an HRS model score for the H.O.D. Landfill site. The data used in the scoring process was based, in part, on information gathered during the July 1984 SI and results of the chemical analysis of groundwater samples collected during the SI. Chemical analysis results of groundwater sampled from monitoring well G103 was used to document a release of contaminants to groundwater for the HRS score.

WMII subsequently had the protector pipe around well G103 removed. WMII suspected that the zinc detected in the well sample was the result of deterioration of the protector pipe, of which at least one section was constructed of galvanized steel. During removal of the protector pipe, the polyvinyl chloride (PVC) well pipe yielded. Well G103 was removed and the borehole was plugged on October 31, 1985. A replacement well (R103) was installed approximately 10 feet south of G103. The well removal and replacement was conducted by TSC (TSC 1985).

At the request of WMII, Dames & Moore conducted a hydrogeologic assessment of the H.O.D. Landfill and surrounding area. The report of this assessment is dated November 12, 1985. In addition to providing a brief summary of past groundwater sampling activities, Dames & Moore summarized and compared the chemical analysis results of samples collected at the site for three parameters: chloride, zinc, and total dissolved solids. The chemical analysis data was from three samples: a water sample collected from village of Antioch well 4 (collected on April 19, 1982), a sample from monitoring well G103 (collected on April 9, 1984), and a leachate sample from the landfill (collected on April 11, 1984) (Dames & Moore 1985).

According to the Dames & Moore report, no high levels of inorganic contamination were detected in the municipal well sample; however, methylene chloride (45 µg/L), trans-1,2-dichloroethylene (9 µg/L),

1,2-dichloropropane (10 µg/L), benzene (21 µg/L), toluene (170 µg/L), and ethylbenzene (230 µg/L) were detected in the leachate sample. The groundwater sample, which was only analyzed for six inorganic parameters, did not contain elevated concentrations of the parameters analyzed for. No comparison of organic analysis of the three samples was conducted (Dames & Moore 1985). The Dames & Moore report concluded the following:

...the H.O.D. Landfill monitoring wells are less than 36 feet deep and monitor groundwater in the shallow saturated zone, well above the aquifer of concern in which the Antioch municipal wells are screened, [and] throughout most of the area, the silty clays, by virtue of their thickness and low permeability, should provide adequate protection for ground water supplies in the area. (Dames & Moore 1985)

However, Dames & Moore also states in the report:

No conclusions can be drawn for the area along the southern boundary of the landfill, as the thickness of the silty clay layer is not presently known in this area. Waste Management of Illinois, Inc., prior to emplacement of waste material in this area, did install a recompacted clay liner in this area (Nelson 1985). (Dames & Moore 1985)

On January 9, 1986, IEPA collected groundwater samples from four residential wells located east of H.O.D. Landfill. The samples were analyzed for nitrates, organic compounds, and trace metals that have established drinking water standards. Chemical analysis results of each sample indicated that no maximum allowable concentrations for trace metals were exceeded and that no organic compounds were detected (IEPA 1986, 1986a, 1986b, 1986c).

3. PROCEDURES

3.1 INTRODUCTION

The following subsections detail procedures used by FIT during field activities of the inspection of the H.O.D. Landfill site. The field activities included a geophysical investigation conducted primarily by U.S. EPA (assisted by FIT) and a hydrogeologic investigation, conducted primarily by FIT, that included the drilling of borings and subsurface soil sample collection, the installation of monitoring wells and streambed well points, the measurement of physical parameters to characterize the aquifers at the site, and the collection of subsurface soil samples and groundwater samples for chemical analysis.

Investigation-derived waste materials, including drilling fluids, soil cuttings, well development and purge water, and disposable protective clothing generated during the field investigation, were placed in 55-gallon drums. These waste materials were then removed from the landfill and disposed of at a U.S. EPA-approved facility.

3.2 GEOPHYSICAL INVESTIGATION

Electromagnetic induction (EMI) surveys were conducted at two areas adjacent to the H.O.D. Landfill property on March 16 and 17, 1987, to characterize subsurface geological features in the areas of proposed monitoring well installations. Specifically, the surveys were conducted to identify the location of the buried channel of the pre-rerouted Sequoit Creek that had crossed the site because a potential exists for the channel to act as a contaminant migration pathway. One survey area

extended off-site adjacent to the southern portion of the eastern site boundary, and the other survey area was located off-site and adjacent to the western portion of the northern site boundary (see Figure 3-1). A grid was established at each survey area. The grid at the southeastern portion of the site was established with north/south lines 20 feet apart and east/west lines 50 feet apart. The grid to the northwest of the site was established with north/south lines 50 feet apart and east/west lines 10 feet apart (U.S. EPA 1989). Measurements of the electrical conductivity of the ground were then obtained at each of the established grid points. A Geonics EM34-3 and a Geonics EM31-D were used for the surveys. (The geophysical investigation report prepared by U.S. EPA is provided in Appendix A.)

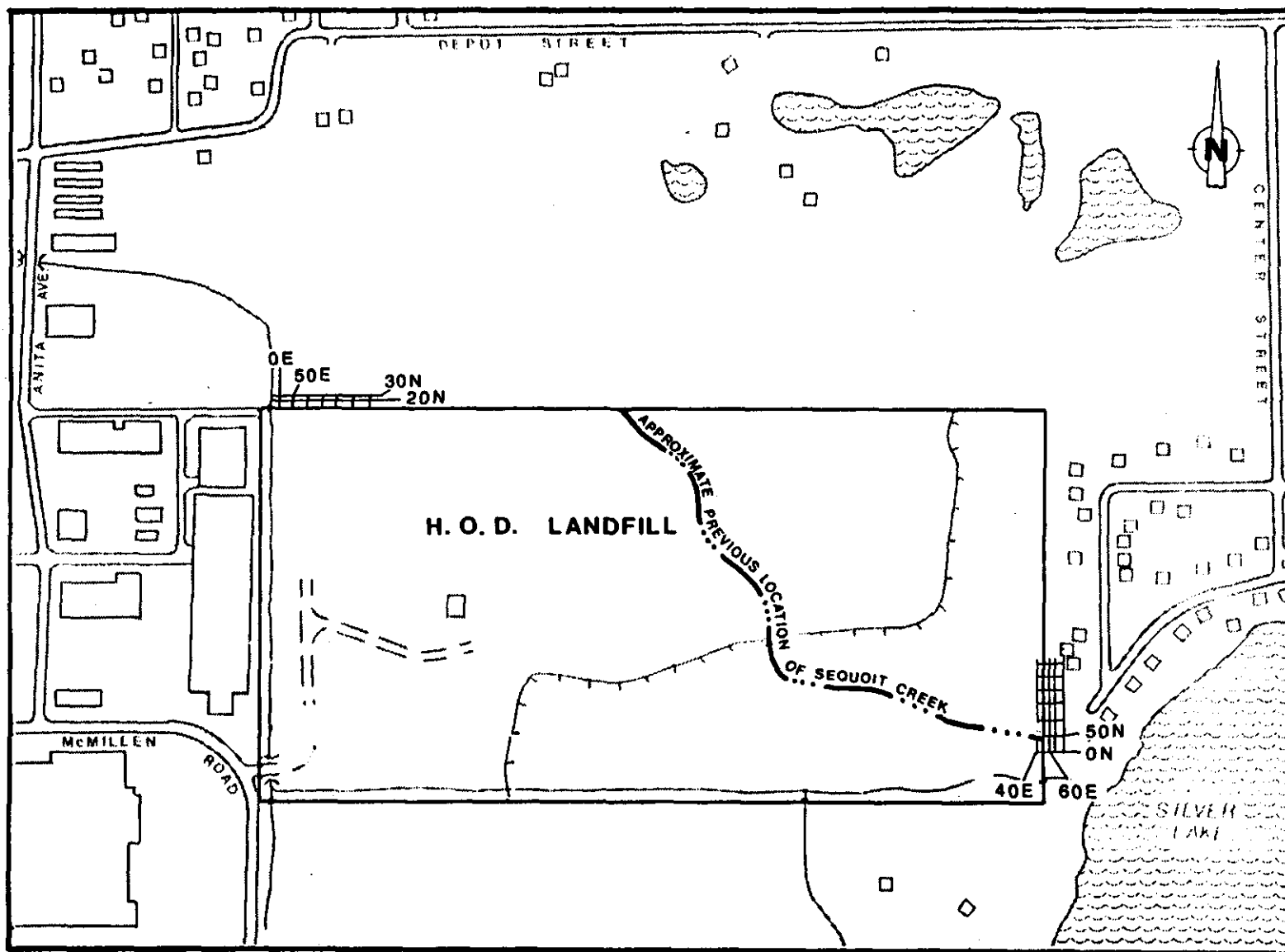
3.3 HYDROGEOLOGIC INVESTIGATION

The FIT-conducted hydrogeologic investigation included the following activities:

- The drilling of 15 borings;
- The installation of 13 monitoring wells;
- Measuring groundwater and surface water elevations;
- Hydraulic conductivity testing;
- Preliminary and primary pump tests to assess the effectiveness of the Wadsworth Till as a confining unit;
and
- The collection of subsurface soil samples and groundwater samples for chemical analysis.

3.3.1 Soil Borings

Fox Drilling, Inc., of Itasca, Illinois, was subcontracted by FIT and conducted all drilling operations for FIT's inspection of the site. Drilling operations were conducted between April 27, 1987, and July 21,



SOURCE: Ecology and Environment, Inc. 1989.



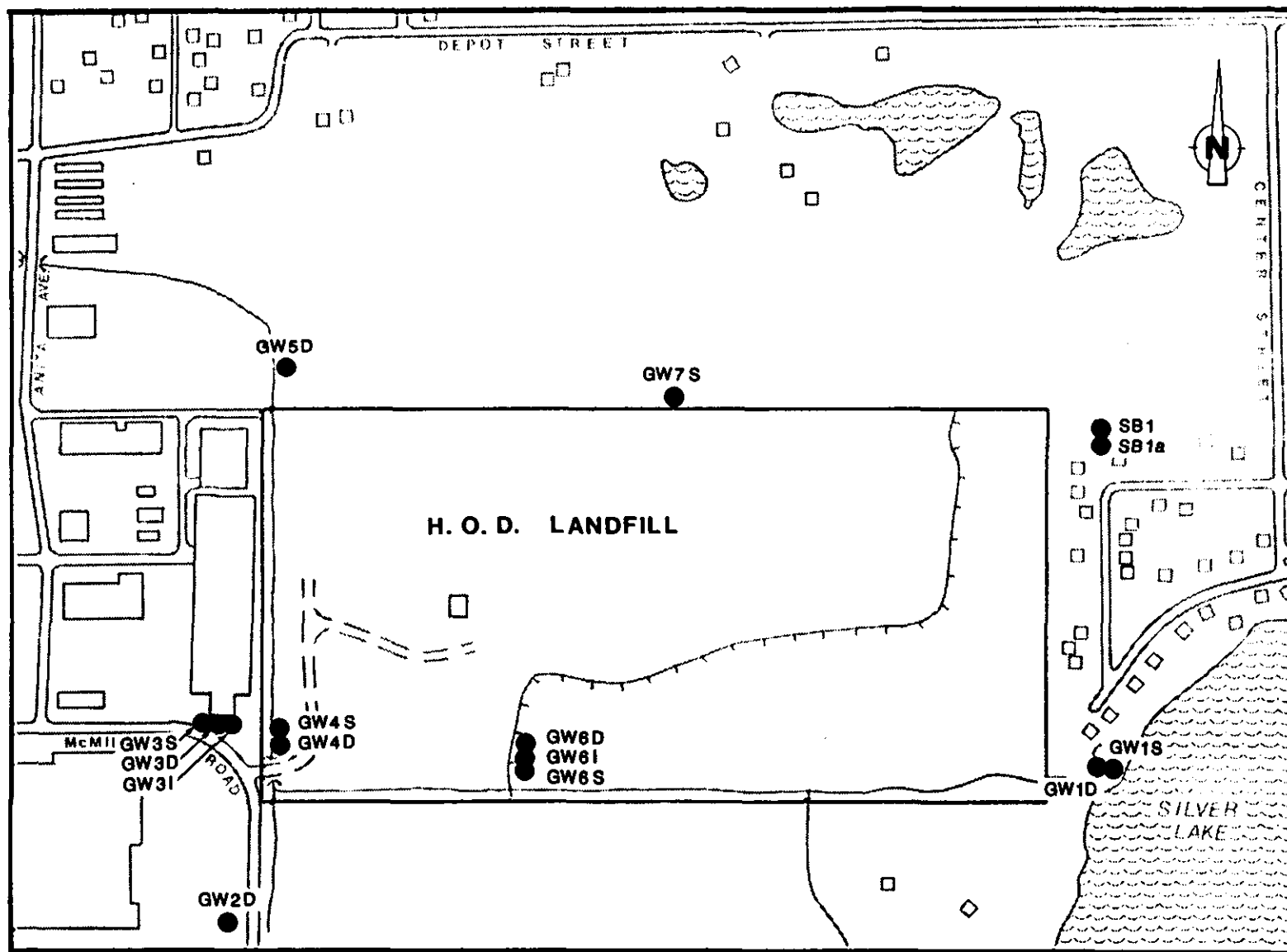
FIGURE 3-1 U.S.EPA ELECTROMAGNETIC INDUCTION SURVEY GRID AREAS

1987. The subcontractor's field crew and drilling equipment were mobilized to the site on April 27, 1987. Stratigraphic borings in which monitoring wells were not installed are denoted by SB preceding the boring location number. Borings in which groundwater monitoring wells were installed are denoted by the prefix GW. A suffix indicates the monitoring well depth relative to the stratigraphy (shallow wells are denoted with an S, referring to wells screened in a saturated zone above the clay till unit; intermediate wells are denoted with an I, referring to wells screened in the clay till unit; deep wells are denoted with a D, referring to wells screened below the clay till unit) (see Figure 3-2 for boring locations). On April 29, 1987, drilling operations at boring SB1 were halted because of subcontract discrepancies. The subcontract discrepancies were ultimately resolved and the subcontractor remobilized to the site on May 18, 1987. Drilling operations resumed at boring SB1a. The subcontractor demobilized on July 21, 1987, upon completion of contract-specified work.

3.3.1.1 Drilling Procedures

Because of the possible separation of the two sand and gravel aquifers by the Wadsworth Till, different drilling methods were used to drill deep and intermediate depth borings as compared to the shallow borings. These different drilling methods were used to prevent the potential intermixing of water between the aquifers. The drilling method used for the deep and intermediate borings (GW1D, GW2D, GW3D, GW4D, GW6D, GW3I, and GW6I), with the exception of borings GW5D, SB1, and SB1a, included the following procedures. (At deep boring locations where the upper sand and gravel unit does not overlie the clay till unit [GW5D, SB1, and SB1a], smaller diameter drill bits were used, and permanent steel casings were not installed.)

- A 10-inch diameter boring was drilled using rotary wash drilling methods until the Wadsworth Till unit was encountered.



SOURCE: Ecology and Environment, Inc. 1989.



FIGURE 3-2 BORING LOCATIONS

- A 6-inch inside diameter (ID) non-galvanized, low-carbon steel casing was lowered into the boring and pushed into the till to obtain a seal.
- The annular space (the space between the casing and the boring wall) was grouted using a high-percentage-bentonite-solids grout specifically designed for sealing well borings. All grouting was conducted from the bottom to the top of the boring using a tremie pipe or small diameter drilling rods.
- The grout was allowed to set for a minimum of 24 hours.
- Drilling fluid was displaced from the cased boring by pumping potable water through a tremie pipe that had been lowered to the approximate bottom of the boring.
- Drilling was then continued beyond the steel casing using a 5 7/8-inch tricone bit and rotary wash methods. A drilling fluid consisting of bentonite and water was used when necessary.

The two intermediate borings (GW3I and GW6I) were drilled using the drilling methods used for deep borings GW1D, GW2D, GW3D, GW4D, and GW6D. However, the intermediate borings were terminated approximately midway through the Wadsworth Till.

The shallow borings (GW1S, GW3S, GW4S, GW6S, and GW7S) were drilled using 6 1/4-inch ID hollow-stem augers.

Prior to the mobilization of the drill rig to each well cluster location or single boring location, the drill rig and drilling equipment were decontaminated using a three-step process that included a high pressure hot-water and detergent-solution spray followed by an acetone wash, and a high-pressure hot-water rinse. Between each boring at a well cluster, the drilling equipment was decontaminated in the same manner. Although some borings were drilled on the landfill property,

no borings were drilled through H.O.D. Landfill debris. Boring depths ranged from 13 to 136.5 feet.

3.3.1.2 Soil Sample Collection Procedures

At single boring locations and at the deepest boring of each cluster location, undisturbed soil samples were collected ahead of the boring by driving a 2-inch outside diameter (OD) split-barrel sampler using a 140-pound weight free falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded and is provided in the boring logs. (Logs of FIT-conducted soil borings and monitoring well installations are provided in Appendix C.) Textural classification of all soil samples collected with split-barrel samplers was conducted by visual inspection.

All soil samples were monitored for volatile and semivolatile contaminants with an organic vapor analyzer (OVA 128) (OVA 128 readings above background are provided in Appendix C). Procedures for the handling of soil samples collected for chemical analysis are presented in 3.3.4.1.

In addition to visual textural classification of the soil samples collected with the split-barrel samplers, two soil samples were collected with a Shelby-tube sampler and transported to a soil testing laboratory. Two falling head permeability and two grain size distribution tests were conducted on each of these soil samples in accordance with American Society for Testing and Materials (ASTM) methods; in addition, one soil sample collected with the split-barrel sampler was analyzed for grain size distribution (also in accordance with ASTM methods). The physical characteristics testing was conducted by P. G. Engineering Associates, Inc., of Chicago, Illinois.

3.3.2 Monitoring Well Construction and Installation

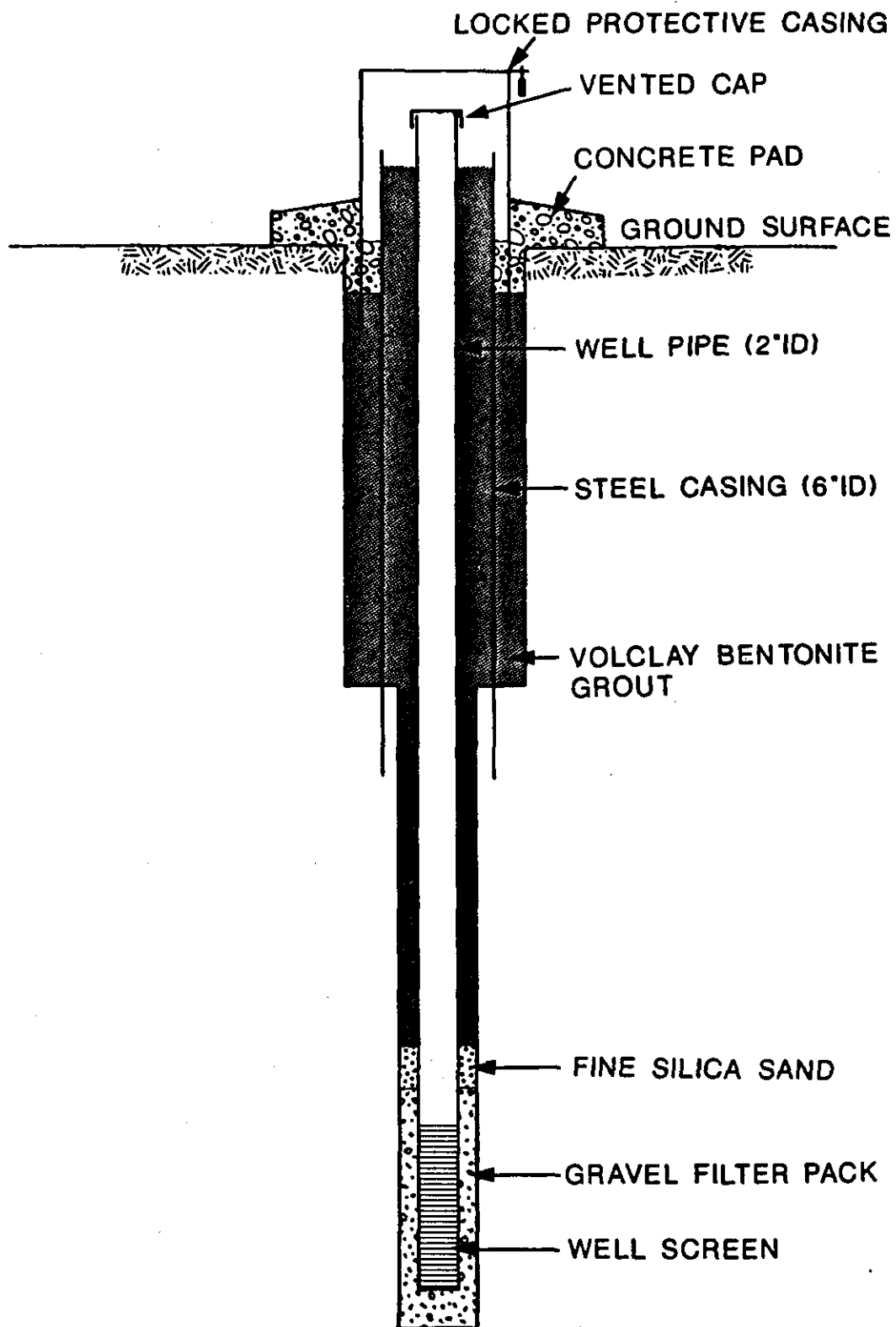
Of the 15 borings drilled at the site, 13 were used for the installation of monitoring wells. Boring locations 1 and 4 each have 2 wells; locations 3 and 6 each have 3 wells; and locations 2, 5, and 7 each have a single well (see Figure 3-2). The wells at the two-well nests consist of one deep and one shallow well; the wells at the three-well nests consist of one deep, one intermediate, and one shallow well.

Single wells at locations 2 and 5 are deep, while the well at location 7 is shallow.

Wells GW2D, GW3I, and GW3D are constructed of PVC well pipe and PVC well screens; these wells were used solely for the collection of hydro-geologic data. Groundwater samples were not collected from any FIT-installed monitoring wells constructed of PVC. All other FIT-installed well casings and well screens were constructed entirely of stainless steel pipes and screens with a nominal ID of 2 inches and flush-threaded joints. Each joint was sealed with Teflon tape prior to installation of the well. The well screens of all FIT-installed wells are of a continuous wound design with a slot size of 0.010 inches. A cap of the same material as the well screen was placed at the bottom of each well screen to prevent the intrusion of filter pack material. The well screens used for each intermediate-depth well were 3 feet in length; well screens used for the shallow and deep wells were 5 feet in length.

Where rotary wash drilling methods were used, the assembled well screen and well casing were lowered into the boring. Potable water was then pumped through a tremie pipe that had been lowered to the approximate bottom of the boring to displace the drilling fluid. Upon displacement of the drilling fluid from the boring, the tremie pipe was removed from the boring and a depth measurement was taken to determine whether the formation surrounding the well screen had collapsed. If the formation had not collapsed to a level above the top of the well screen, gravel filter pack material was then placed into the borehole to a level approximately 3 feet above the top of the well screen. A 1-foot-thick layer of fine silica sand was then placed above the gravel filter pack material. The remainder of the boring was grouted from the fine silica sand to within 3 feet of the ground surface with Volclay grout. Volclay grout is a high-percentage-bentonite-solids grout specifically designed for sealing well borings (see Figure 3-3 for an illustration of the type of double-cased well construction used by FIT).

At borings where hollow-stem augers were used to drill the boring, the assembled well was lowered through the center of the augers to the desired depth. As the augers were removed from the boring, gravel filter pack material was added to a level approximately 3 feet above the



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 3-3 TYPE OF DOUBLE-CASED WELL CONSTRUCTION USED BY FIT AT H.O.D. LANDFILL

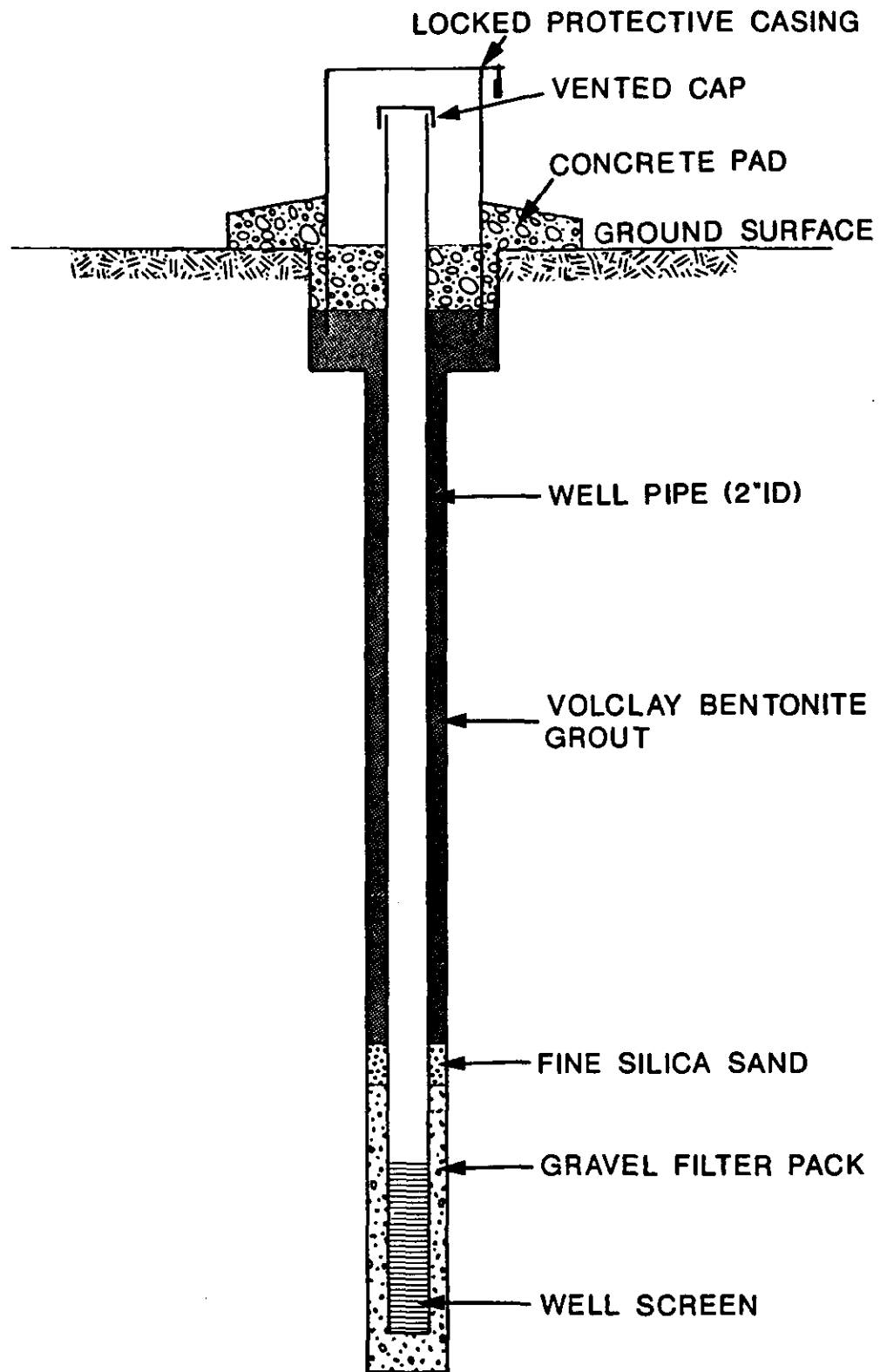
top of the well screen followed by a 1-foot-thick layer of silica sand. The remainder of the boring was grouted using a tremie pipe as the augers were removed from the boring (see Figure 3-4 for an illustration of the type of single-cased well construction used by FIT).

Vented caps constructed of the same material as the well were installed at the top of all FIT-installed wells. To provide well security, a steel casing of 8-inch nominal ID and 5-foot length was centered around each monitoring well casing and set in concrete. The top of the protective casing that extended above the well casing was fitted with an overlapping cap and secured with a padlock. Each protective casing was surrounded by a concrete slab approximately 3 feet by 3 feet in size. Each pad was poured on the ground surface, is approximately 4 inches thick, and has a surface that slopes away from the casing to provide drainage away from the well. A hole was placed in each protective casing near the surface of the concrete pad to allow for drainage of any water that could potentially accumulate in the casing. In areas where vehicular traffic is expected, 4-inch diameter steel bumper posts 8 feet in length were placed at each well to protect the well from collision damage. Each bumper post was placed in a 4-foot deep boring. The posts and the borings were then filled with concrete.

Upon completion of the installation of all monitoring wells, each well was developed using an air lift method. Breathing quality air (grade D) (American National Standard, Commodity Specification for Air 1973) was forced down a polyethylene tube outside of a PVC tremie pipe that had been lowered into the well. Brass pipe fittings were used to make a 180-degree turn in the polyethylene tube at the base of the tremie pipe. The polyethylene tube was fastened to the tremie pipe so that one end of the tubing extended up into the tremie pipe, forcing well water out the top of the tremie pipe. A minimum of 10 volumes of water was removed from each well. All monitoring well development water was placed in 55-gallon drums for off-site disposal.

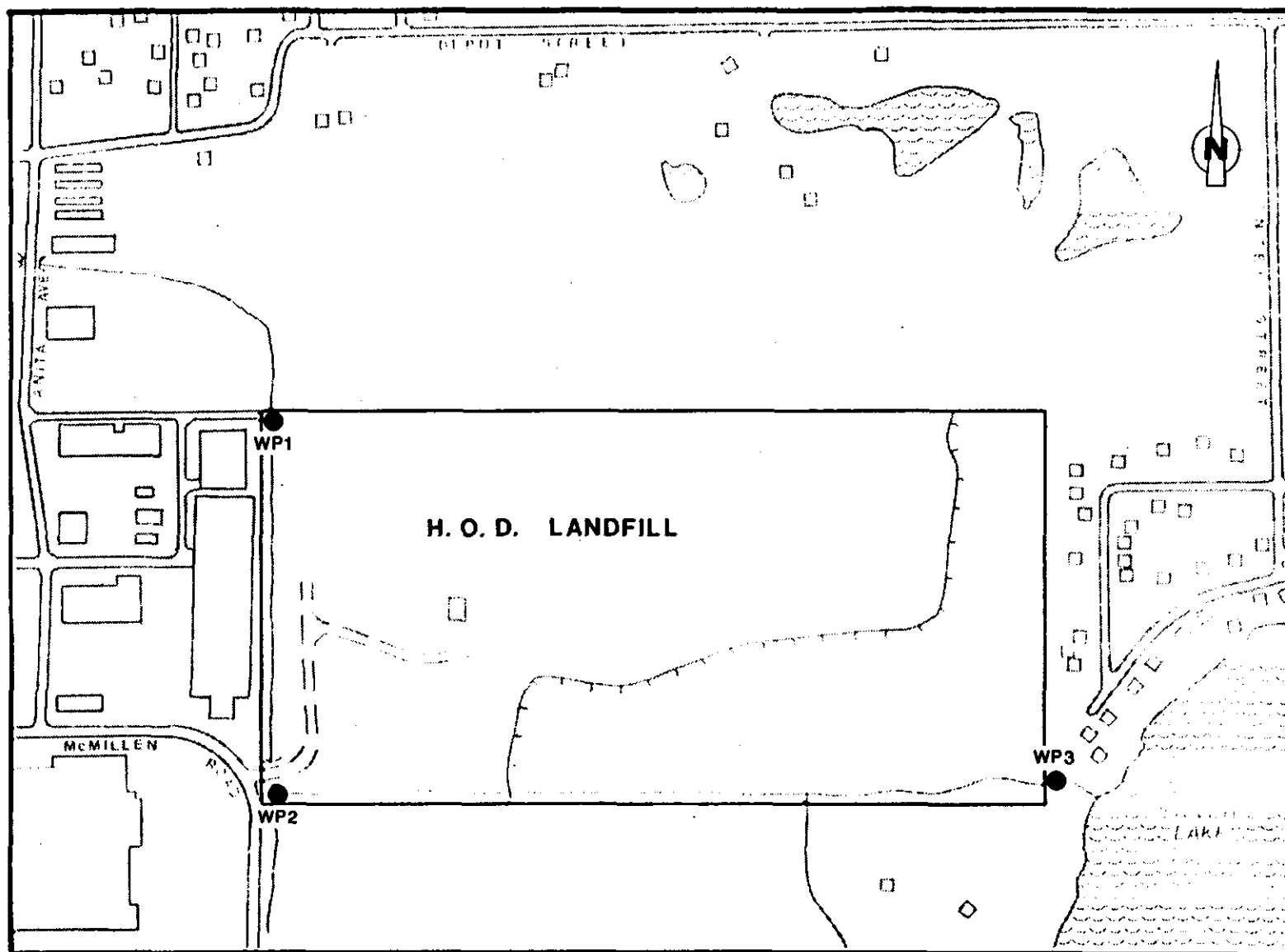
3.3.3 Physical Aquifer Measurements

Streambed well points were installed by FIT in Sequoit Creek on October 14, 1987 (see Figure 3-5 for well point locations). Measurements of the water surface of Sequoit Creek and static groundwater



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 3-4 TYPE OF SINGLE-CASED WELL CONSTRUCTION USED BY FIT AT H.O.D. LANDFILL



SOURCE: Ecology and Environment, Inc. 1989.



FIGURE 3-5 SEQUOIT CREEK WELL POINT LOCATIONS

elevations were taken by FIT on November 13, 1987, and May 19, 1988, to evaluate the interaction of groundwater and Sequoit Creek.

Physical parameters of the sand and gravel aquifers and the Wadsworth Till were characterized by in situ methods, which included static water level measurements, slug tests, and pump tests.

Water level measurements included both static water elevation measurements and measurements of the water levels versus time during the slug tests and pump tests. Static water level measurements were used to develop potentiometric surface maps and to calculate horizontal hydraulic gradients (see Figures 4-4 through 4-7 for potentiometric surface maps). Slug test data were used to calculate the in situ horizontal hydraulic conductivities of the screened segment of the aquifers using the FIT-installed monitoring wells. Pump test data were used to determine drawdown, transmissivity, and storativity characteristics of the aquifers.

3.3.3.1 Sequoit Creek/Groundwater Water Surface Measurements

The data used to determine the interaction between groundwater and Sequoit Creek were obtained from the three well points that had been installed in Sequoit Creek by FIT. The screened portion of each well point was 2 feet in length and was constructed of number 80 gauze mesh. The screened portion of each well point was threaded to 1 1/4-inch ID galvanized steel pipe. Each assembled well point was driven into the streambed of Sequoit Creek so that the top of the screen was at least 2 1/2 feet, but not more than 4 feet, below the surface of the streambed. Each installed well point was covered with a vented, threaded cap. Each well point was then developed using a bailer.

The elevation of the top of each well point was surveyed and then the distance to surface water was measured from the top of each galvanized steel pipe. The distance to groundwater was measured using a chalked steel tape inside each well point. The measurements of the distance to surface water and the measurements of the distance to groundwater were subtracted from the elevation of the top of the well point, yielding elevations for the surface water and groundwater.

3.3.3.2 Static Groundwater Measurements

Static groundwater elevations were determined by surveying the elevation of the top of the inside casing (TIC) of each FIT-installed monitoring well, and measuring the distance to water from the TIC of each monitoring well (measured with a chalked steel tape). The distance to water from the TIC was then subtracted from the TIC elevation. The steel tape was decontaminated prior to use at each well with a solution of detergent (Alconox) and water, and rinsed with distilled water.

3.3.3.3 Horizontal Hydraulic Conductivity Testing

Rising head slug tests were conducted by FIT and U.S. EPA on September 10 and 11, 1987; an additional slug test was conducted by FIT on September 21, 1987. The rising head slug tests at the FIT-installed monitoring wells were conducted by FIT using an In-Situ SE1000A Hermit data logger. U.S. EPA slug tests were conducted using an In-Situ SE1000B Hermit data logger. Data obtained during the slug tests were used to calculate the in situ horizontal hydraulic conductivity of the screened segment of the aquifers and the Wadsworth Till. Horizontal hydraulic conductivities were then used to calculate horizontal groundwater velocities. The following field procedures were followed at each well to gather the rising head slug test data.

- The static water level measurement was recorded. A chalked steel tape was used to obtain this measurement.
- The probe of the data logger was lowered into the well to a level ranging from 5 to 15 feet below the static water level. An initial data logger reading was then recorded. (The data logger displays the length, in feet, of the column of water above the probe. This value is referred to as the head.)
- A sealed, sand-filled slug constructed of 1 1/4-inch ID PVC pipe 5 feet in length was lowered into the monitoring well being tested, displacing a known volume of water.

- The head value was monitored with the data logger until it equilibrated to the initial pre-slug level.
- The slug was removed from the well and the data logger was set to record the head values at predetermined time intervals. Values were recorded until the head rose to its initial level.
- When the original water level was reached, the slug test was terminated. The data were stored for later evaluation.

Because of the slow recharge rate of groundwater in well GW3I, a falling head slug test was conducted by U.S. EPA at the well. For a falling head slug test, the initial water level reading is recorded as in a rising head slug test. However, water level data are recorded upon placing the slug into the well. Data are recorded until the water level equilibrates to its initial level.

3.3.3.4 Preliminary Pump Test

A preliminary pump test was conducted in an attempt to determine initial estimates of transmissivity and storativity of the lower sand and gravel aquifer and to assist in the design of the primary pump test.

The preliminary pump test was conducted jointly by U.S. EPA, FIT, and USGS from September 21 through 24, 1987.

Three days prior to the commencement of the preliminary pump test, the village of Antioch altered its municipal well pumping schedule in an effort to stabilize the groundwater levels in the vicinity of H.O.D. Landfill. During this 3-day period, four of the five municipal wells were turned off; only well 5, a large capacity well, pumped. Also during this 3-day period, water levels in wells GW1S and GW1D were measured and recorded at 1/2-hour intervals using an In-Situ SE1000B Hermit data logger. Water levels at wells GW2D, GW3S, GW3I, GW3D, and GW4D were measured for 12 hours prior to the start of the pump test at 1/2-hour intervals. An In-Situ SE1000A Hermit data logger was used to record water levels in well GW2D. Water levels in wells GW3S, GW3I, GW3D, and GW4D were monitored with an In-Situ SE2000 Hermit data logger.

Municipal well 4 was chosen as the discharge well for the preliminary pump test because of its proximity to both the landfill and monitoring wells and because of its high yield. Because of the low pumping rate of well 1 and its distance from the study area, it was pumped during the test.

Municipal well 4 was turned on at approximately 7:00 a.m. on September 24, 1987. However, U.S. EPA, FIT, and USGS were not immediately notified. As a result, the data loggers were not turned on until 7:25 a.m. The data loggers at each monitoring well were programmed to record water level measurements on a logarithmic time scale. In addition to the data logger measurements, steel tape measurements of water levels were recorded from all FIT-installed wells at approximately 2-hour intervals throughout the day.

To commence the pump test, municipal well 5 was turned off and municipal wells 1 and 4 were turned on. According to a city well gauge, which was monitored periodically throughout the preliminary pump test, municipal well 4 pumped at 525 gpm. The pump test lasted 8 1/2 hours. Several hours into the pump test (exact time unknown), demand for water exceeded the pumping rate of municipal wells 4 and 1 and municipal well 5 automatically activated to meet the additional demands on the municipal water supply system. Municipal well 5 was turned off later during the test. The exact pumping durations and rates of well 5 were not recorded during the pump test. Municipal wells 4 and 1 were turned off upon completion of the pump test. Well 5 was activated shortly after completion of the pump test. However, monitoring well water level measurements were recorded for an additional 3 1/2 hours to gather recovery test data.

3.3.3.5 Primary Pump Test

The primary pump test consisted of three stages: a pre-pump stage (72 hours of water level monitoring in all FIT-installed monitoring wells), a 24-hour pump test, and a 24-hour recovery test. The work was completed during the week of December 14 through 19, 1987, and was conducted jointly by U.S. EPA, FIT, and USGS.

Three days prior to the primary pump test, the village of Antioch altered its municipal well pumping schedule. In an effort to stabilize

the groundwater levels in the vicinity of H.O.D. Landfill, four of the five municipal wells were turned off. Demands on the municipal water supply system were met by municipal well 5, a large capacity well. However, municipal wells 1 and 2 pumped for approximately 2 1/2 hours immediately prior to the pump test to meet additional demands on the municipal water supply system.

Throughout the test, the pumping rates of municipal wells 3, 4, and 5 were recorded on a regular basis, and water level measurements of all FIT-installed monitoring wells were recorded at 3-hour intervals. During the pre-pumping stage, monitoring well water levels were measured with either a chalked steel tape or an electric water level indicator. During the pumping and recovery stages, water levels in all FIT-installed monitoring wells were measured with steel tapes. Each steel tape was decontaminated prior to each measurement with a solution of Alconox and water, and rinsed with distilled water. Water levels of WMII well G102 were also measured during the pumping and recovery stages using a steel tape dedicated for use at that well only.

FIT-installed monitoring wells GW1S, GW1D, GW2D, GW3S, GW3I, GW3D, GW4D, GW6S, GW6I, and GW6D, and WMII monitoring well G102 were used for the pumping and recovery stages of the pump test. To commence the pumping stage of the test, municipal wells 1, 2, and 5 were turned off, and well 4 was turned on. Municipal well 4 pumped for the duration of the pumping stage. During the last 4 hours of the pumping stage, municipal well 1 also pumped to meet additional demands on the municipal water supply system. The duration of the pump test was approximately 24 1/2 hours. Upon completion of the pumping stage, a recovery test was initiated. The recovery test began when municipal wells 1 and 4 were turned off. However, municipal well 5 began pumping to meet demands on the municipal water supply system 12 minutes into the recovery test. The duration of the recovery test was approximately 24 hours.

Water levels in wells GW1S and GW1D were recorded at 1/2-hour intervals with an In-Situ SE1000B Hermit data logger during the entire week of water level monitoring. Water levels in wells GW2D, GW3S, and GW3I were recorded at 1/2-hour intervals during the 72-hour pre-pump stage and on logarithmic time scales during the pump test and recovery test using USGS-owned microswitch pressure transducers.

A USGS-owned pressure transducer was also used at well GW6S; well GW6S was monitored only during the pump and recovery tests using logarithmic time scales. Well GW3D was monitored only during the pump and recovery tests with an In-Situ SE1000A Hermit data logger; water levels were recorded on a logarithmic time scale for each test. Wells GW6I and GW6D were monitored with an In-Situ SE1000B Hermit data logger; wells GW4D and WMII well G102 were also monitored with an In-Situ SE1000B Hermit data logger. The water levels in each of these wells were recorded at 1/2-hour intervals for 12 hours immediately preceding the pump test. The water levels were recorded on logarithmic time scales for both the pump and recovery tests. A second USGS-owned transducer was placed in WMII well G102 to record water levels, also on a logarithmic time scale, during the recovery test.

Ancillary data collected during the week of the primary pump test included barometric pressure, streambed well point water elevations, and Sequoit Creek and Silver Lake water elevations.

3.3.4 Sampling for Chemical Analysis

Selected subsurface soil samples collected during the drilling phase of the project and groundwater samples collected from FIT-installed and WMII monitoring wells, residential wells, and village of Antioch municipal well 4 were analyzed for U.S. EPA Target Compound List (TCL) compounds and Target Analyte List (TAL) analytes.

3.3.4.1 Soil Sampling

A total of 49 subsurface soil samples (S1 through S49) were collected from seven borings (GW1D, GW2D, GW3D, GW4D, GW5D, GW6D, and GW7S) (see Figure 3-2) for chemical analysis. (The boring number each sample was collected from, the date of sample collection, and the depth of each sample within the boring are presented in Table 4-17.) Each sample was collected using a split-barrel sampler. A vertical series of samples was collected from the till encountered at each of the seven borings to determine whether contaminants had migrated downward through the till. Prior to the collection of samples at each boring, the split-barrel samplers were decontaminated in the same manner described in 3.3.1.1. Between samples within a boring, the split-barrel samplers

were scrubbed in a solution of Alconox and water, rinsed with potable water, then rinsed with acetone, and finally rinsed with distilled water.

A portion of the middle one-third of the sample material was placed into two 120 ml glass sample jars for volatile organic compound (VOC) analysis. The remaining two-thirds of each sample was mixed and placed into two 8 oz. sample jars to be analyzed for semivolatile compounds, pesticides, PCBs, metals, and cyanide. The samples were immediately placed in a cooler with ice prior to being transported to FIT's off-site trailer/office for labeling and packaging.

Samples were shipped to U.S. EPA Contract Laboratory Program (CLP) laboratories via an overnight delivery service using standard U.S. EPA chain-of-custody procedures. All samples were shipped on the day of collection.

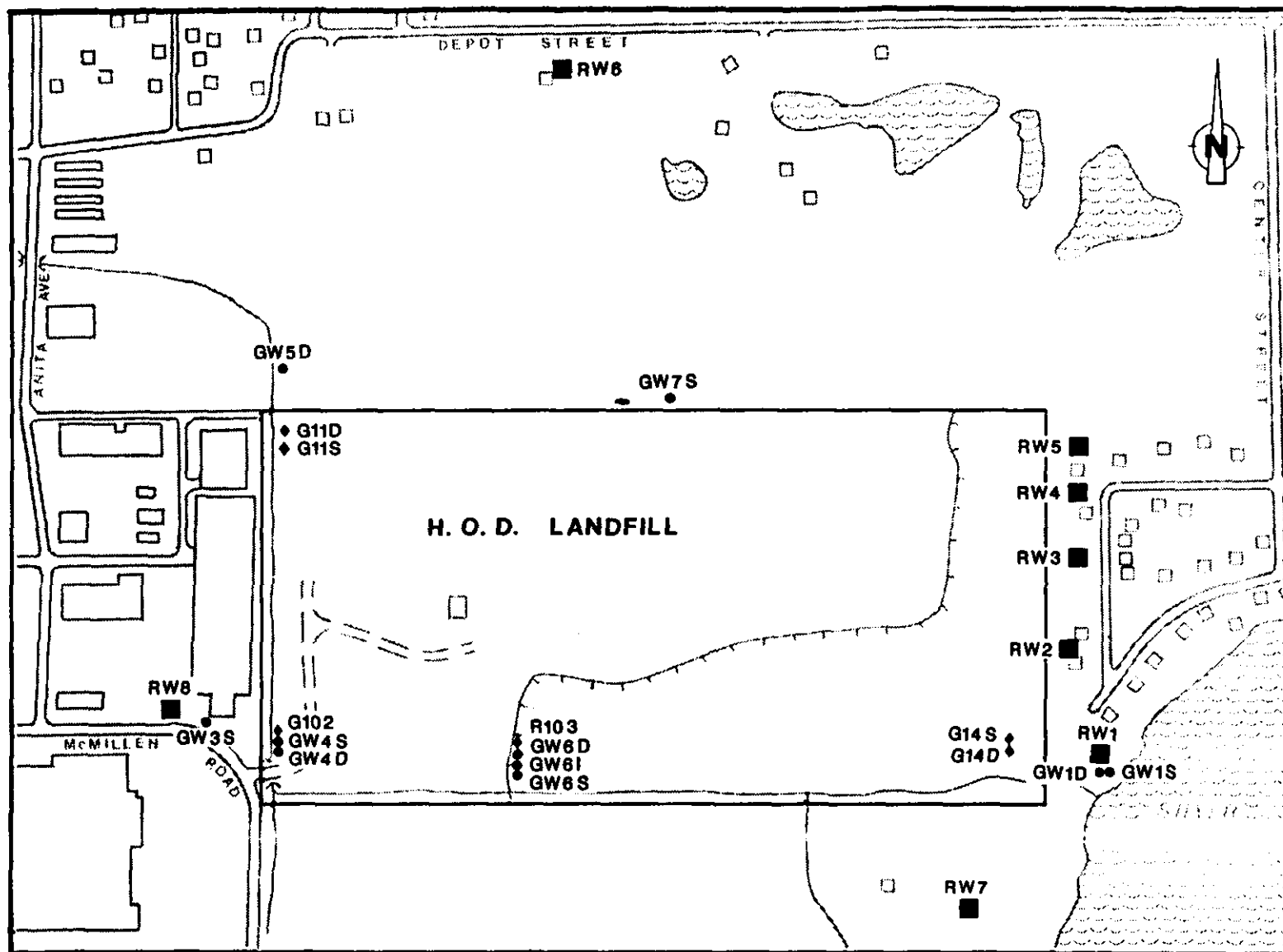
All soil samples were analyzed for TCL compounds by Rocky Mountain Analytical Lab of Arvada, Colorado, and for TAL analytes by Envirodyne Engineers of St. Louis, Missouri.

3.3.4.2 Groundwater Sampling

Groundwater samples were collected from wells on and in the vicinity of the H.O.D. Landfill site for chemical analysis. Three rounds of groundwater samples were collected and submitted for analysis (see Figure 3-6 for groundwater sampling locations).

Round 1--August 10, 11, and 12, 1987. Groundwater samples were collected for chemical analysis from 15 monitoring wells and 8 drinking water wells (GW1S, GW2D, GW3S, GW4S, GW4D, GW5D, GW6S, GW6I, GW6D, GW7S, G11D, G102, R103, G14S, G14D, and RW1 through RW8). The monitoring wells sampled included WMII wells and FIT-installed wells. WMII well G11S had been planned to be sampled by FIT but did not contain a sufficient volume of water for sample collection. Drinking water samples were collected from residential wells and village of Antioch municipal well 4 (see Table 3-1 for addresses of drinking water sampling locations).

Prior to sample collection, the volume of standing water in each monitoring well was calculated and a minimum of three to five volumes of water was purged or the wells were purged dry, whichever occurred first.



SOURCE: Ecology and Environment, Inc. 1989.



- LEGEND
- FIT-INSTALLED MONITORING WELLS
 - ◆ WMII MONITORING WELLS
 - DRINKING WATER SAMPLING LOCATIONS

FIGURE 3-6 GROUNDWATER SAMPLING LOCATIONS

Table 3-1

ADDRESSES OF DRINKING WATER SAMPLING LOCATIONS

Sample	Address
RW1	22731 W. Silver Lake Ave. Antioch, IL 60002
RW2	42116 N. Lakeview Dr. Antioch, IL 60002
RW3	42164 N. Lakeview Dr. Antioch, IL 60002
RW4	42206 N. Lakeview Dr. Antioch, IL 60002
RW5	42236 N. Lakeview Dr. Antioch, IL 60002
RW6	23067 W. Depot St. Antioch, IL 60002
RW7	22950 W. Route 173 Antioch, IL 60002
RW8	Antioch Municipal Well 4 67 McMillan Rd. Antioch, IL 60002

Source: Ecology and Environment, Inc. 1989.

FIT-installed wells were purged with bottom loading Teflon bailers suspended by nylon rope. New nylon rope was used at each well. The Teflon bailers were decontaminated prior to the collection of each monitoring well sample. The procedure used for decontaminating the bailers included the washing of each bailer with a solution of Alconox and potable water followed by a distilled water rinse. During the bailing process, precautions were taken to prevent the rope and bailer from contacting the ground. This was accomplished by placing a sheet of plastic, with dimensions of approximately 5 feet by 5 feet, around the well casing, which covered the concrete pad and the surrounding ground surface. A 5-gallon polyethylene bucket was used to contain the slack end of the rope as the bailer was raised from the well. A second polyethylene bucket was used to contain the purge water. All purge water from FIT-installed wells was transferred to 55-gallon drums for disposal.

WMII monitoring wells were equipped with a dedicated bladder pump system (Well Wizard). The WMII wells were purged and sampled using the Well Wizard pumps. All purge water from WMII wells was discharged to the ground surface on the downhill side of each well. Purging and sampling of the WMII wells were conducted by Gulf Coast Laboratory (GCL), representatives of WMII. GCL collected samples from WMII wells in accordance with WMII protocols and provided the samples to FIT. GCL did not retain samples from WMII wells.

In addition to monitoring well samples, three field blank samples were prepared by pouring distilled water into a bailer and then emptying the bailer into sample bottles; one duplicate monitoring well sample was collected at well GW6S. FIT offered portions of all FIT-installed monitoring well samples to GCL. GCL accepted the offer and took portions of the samples.

All samples retained by FIT were handled, packaged, and shipped in accordance with U.S. EPA-required procedures. The samples were shipped to a U.S. EPA CLP laboratory on the day of sample collection. Prior to shipping, samples collected for cyanide analysis were preserved with sodium hydroxide. Samples collected for metals analysis were passed through a 0.45 micron membrane filter and preserved with nitric acid. Filtering was conducted using a peristaltic pump with replaceable filter

membranes. The pump was decontaminated with distilled water and the filter was replaced prior to the filtering of each sample.

As directed by U.S. EPA, all samples were analyzed for TCL compounds and TAL analytes by Spectrix-Division of K.E.R. of Houston, Texas.

Drinking water samples were collected by FIT from seven residential wells and village of Antioch municipal well 4. These wells are located in the vicinity of H.O.D. Landfill. In addition to the drinking water samples, a distilled water field blank was collected. A duplicate drinking water sample of the village of Antioch municipal well 4 was also collected. An LCHD representative also collected samples from the drinking water wells. GCL did not collect drinking water samples.

Prior to the collection of each residential well sample, the water was allowed to run for a minimum of 20 minutes. Water softeners and water treatment systems were bypassed for the collection of samples where possible. However, the water softeners at sampling locations RW1 and RW4 could not be bypassed. Village of Antioch municipal well 4 was pumping prior to, and during, sample collection at the well. The municipal water sample was obtained from a spigot valve in the pump house. Water was allowed to run from the spigot valve for several minutes prior to sample collection.

All drinking water samples collected by FIT were shipped on the day of sample collection. As directed by U.S. EPA, all samples were analyzed for TCL compounds by California Analytical Labs of West Sacramento, California, and for TAL analytes by Chemtech Consulting Group of New York, New York. Samples collected for cyanide analysis were preserved with sodium hydroxide, and samples collected for metals analysis were preserved with nitric acid.

Round 2--April 18 and 19, 1988. Round 2 groundwater samples were collected by FIT and U.S. EPA for VOC analysis only from 10 monitoring wells (GW1S, GW1D, GW3S, GW4S, GW4D, GW6S, GW6I, GW6D, GW7S, and WMII well G102).

Prior to sample collection, the volume of standing water in each monitoring well was calculated. A minimum of five volumes of water was purged from each well, with the exception of GW4S; four samples were collected from GW4S, and specific well volumes were purged from the well

prior to the collection of each sample. FIT-installed wells were purged and sampled using a Fultz pump (a Fultz pump is a down-hole submersible pump with Teflon discharge tubing designed for groundwater sample collection from 2-inch ID wells).

A Fultz pump was used by FIT to collect round 2 groundwater samples in response to comments made by WMII regarding round 1 groundwater sampling procedures and results. It was the opinion of WMII that the analytical results of the sample collected from well GW4S were biased because of the presence of landfill gas within the well head space (WMII 1987). Therefore, precautions were taken by FIT during the purging and sampling of each well to maintain a groundwater level above the well screen. This was accomplished by keeping the Fultz pump above the well screen. Groundwater samples of each FIT-installed well were pumped directly into two 120 ml sample bottles from the discharge tube of the Fultz pump. Four groundwater samples were collected from well GW4S, one sample each, after the removal of 1, 3, 6, and 10 well volumes of purge water. A groundwater sample obtained from WMII well G102 was collected by GCL using the Well Wizard system dedicated to the well and was provided to FIT.

In addition to monitoring well samples, two distilled water field blank samples were collected. One duplicate monitoring well sample was also collected from well GW6I. GCL oversaw FIT and U.S. EPA during the sample collection procedures, but did not take portions of any samples. As directed by U.S. EPA, prior to use at each well, the Fultz pump was decontaminated by pumping a detergent and water solution through the pump and the tubing, followed by a potable water rinse. Distilled water was then pumped through the pump and tubing.

All monitoring well purge water and decontamination water, with the exception of purge water from WMII well G102, was containerized in 55-gallon drums for disposal. Purge water from WMII well G102 was pumped to the ground surface on the downhill side of the well.

All samples were handled, packaged, and shipped in accordance with U.S. EPA-required procedures. The samples were shipped to a U.S. EPA CLP laboratory on the day of collection. As directed by U.S. EPA, all samples were analyzed for VOCs by Aquatec, Inc., of South Burlington, Vermont.

Round 3--May 19, 1988. Round 3 groundwater samples were collected by FIT and U.S. EPA from five FIT-installed monitoring wells (GW1S, GW1D, GW4D, GW6I, and GW6D) for VOC analysis only.

Prior to sample collection, the volume of standing water in each monitoring well was calculated. A minimum of five volumes of water was purged from each well prior to sample collection. FIT-installed wells were purged and sampled using a Fultz pump. GCL oversaw FIT and U.S. EPA sampling activities during round 3.

All samples were handled, packaged, and shipped in accordance with U.S. EPA-required procedures. The samples were shipped to a U.S. EPA CLP laboratory on the day of collection. As directed by U.S. EPA, all samples were analyzed for VOCs by S-Cubed of San Diego, California.

4. RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

Results of the field investigation activities conducted at the H.O.D. Landfill site are presented and discussed in the following subsections. The physical results and discussions subsection describes site geology and hydrogeology. The chemical results and discussions subsection presents chemical analysis results of FIT-collected soil samples and three rounds of groundwater sampling that included the collection of monitoring well samples and drinking water samples.

4.2 PHYSICAL RESULTS AND DISCUSSIONS

Physical data, including EMI surveys, soil sample descriptions, soil sample analysis results for physical characterization, groundwater elevation measurements, slug test data, and pump test data are presented and discussed in this subsection.

4.2.1 Site Geology

The site geology was characterized by interpreting data gathered during the U.S. EPA-conducted geophysical investigation, visual observations of soil samples collected during the FIT hydrogeologic investigation, and the background data search.

4.2.1.1 Geophysical Investigation

The following results and discussion summarize the geophysical investigation conducted by U.S. EPA at the H.O.D. Landfill site on

March 16 and 17, 1987. U.S. EPA conducted EMI surveys at two locations at the site (see Figure 3-1).

Results. A summary report of the U.S. EPA-conducted EMI survey including field procedures, results, and conclusions is provided in Appendix A.

Discussion. The EMI data was used by U.S. EPA to prepare contour maps of equal electrical conductivities at each survey area. Erratic data known to be anomalous because of man-made surficial objects were not used in developing the contour maps. The EMI survey results did not identify subsurface conditions indicative of a clearly defined stream channel at either study area (U.S. EPA 1987).

The lowest conductivity values were obtained at the southeastern survey area and trend in a northwest/southeast orientation, passing through the center of the survey area. This area is indicative of a coarse-textured soil and is a possible location of the pre-rerouted Sequoit Creek channel. However, the changes in conductivity are minimal and diminish with depth. A sharp delineation of conductivity values was not detected. Because of the lack of a definitive conductivity boundary, the presence of a sand and gravel-filled channel was not able to be conclusively determined in the southeastern survey area at the depths studied. Conductivity values in the southeastern survey area ranged from 13 to 76 millimhos per meter (mmho/m) (U.S. EPA 1987).

Conductivity values of the northwestern survey area range from -295 to 345 mmho/m. The values are indicative of buried, highly conductive materials, and were very erratic as the depth increased (U.S. EPA 1987). Given these erratic values, it was not possible to conclusively identify the location of the pre-rerouted Sequoit Creek channel in the northwestern survey area; however, the identification of these buried materials aided FIT in choosing monitoring well installation locations in the area.

4.2.1.2 Soil Borings

Characterization of the site geology was also based on visual inspection of soil samples collected during the drilling of soil borings, grain size distribution analysis of three soil samples, and permeability tests of two soil samples. (Descriptions of the soil samples are

included in the logs of FIT-conducted soil borings, which are provided in Appendix C.)

Based on logs of the soil borings, a generalized fence diagram of the site area was developed (see Figure 4-1 for generalized cross section locations and Figure 4-2 for the generalized fence diagram). A north/south geologic cross section (A-C) has been prepared to more clearly illustrate the stratigraphy of the site area, which is not apparent in the fence diagram (see Figure 4-3).

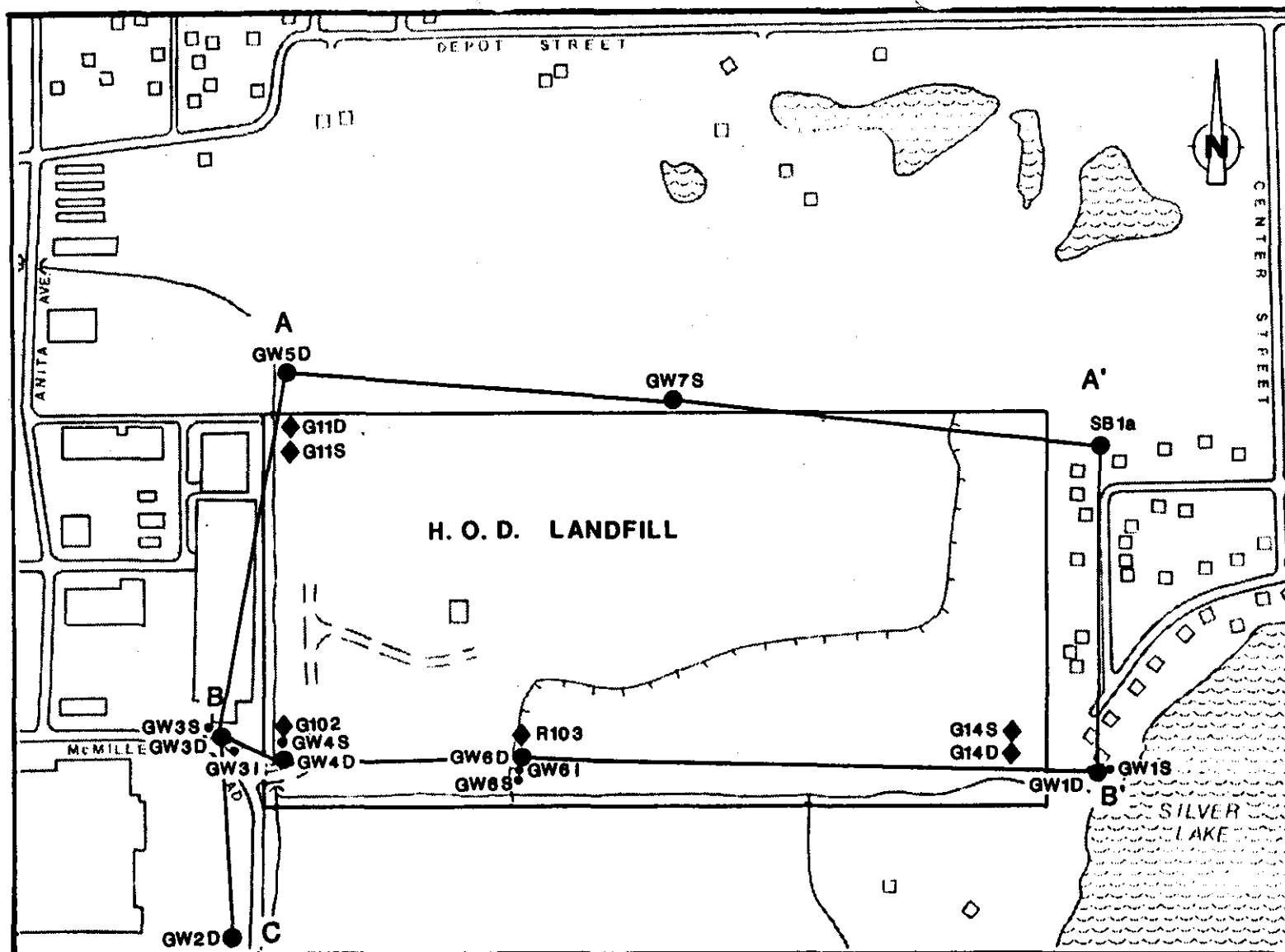
Results. Descriptions of subsurface soil samples indicate that the H.O.D. Landfill site area is underlain by differentiated deposits of sand, gravel, and silty clay. Lenses and thin interbedded units of clay, silt, sand, and gravel are common. Several shallow lenses of organic-rich clay were encountered while drilling borings GW4D and GW6D.

Surficial deposits include clayey to gravelly topsoil and peat and fill material (disturbed soil). The surficial deposits range in thickness from approximately 2 to 9 feet.

The silty clay till is typically light gray to dark gray in color. Thin silt seams and sand seams are common within the silty clay unit. Lenses of clay and gravelly clay exist within the silty clay unit but are less prevalent than the thin silt seams and sand seams. The silty clay deposit is thicker at the northern boundary of the site than at the southern boundary of the site. Yellowish brown and brownish gray clay to silty clay is common at the upper and lower boundaries of the gray silty clay unit.

Sand and gravel deposits in the site area occur as two separate units. The upper unit is a shallow sand and gravel deposit that begins at depths ranging from 7.5 to 20 feet and ranges in thickness from 0 to 35 feet. At borings GW1D, GW4D, and GW6D, deposits of either silt or organic clay overlie the upper sand and gravel unit. The thicknesses of these deposits range from several inches to 11 feet. A lower sand and gravel deposit begins at depths ranging from 70 to 95 feet and underlies the gray silty clay unit.

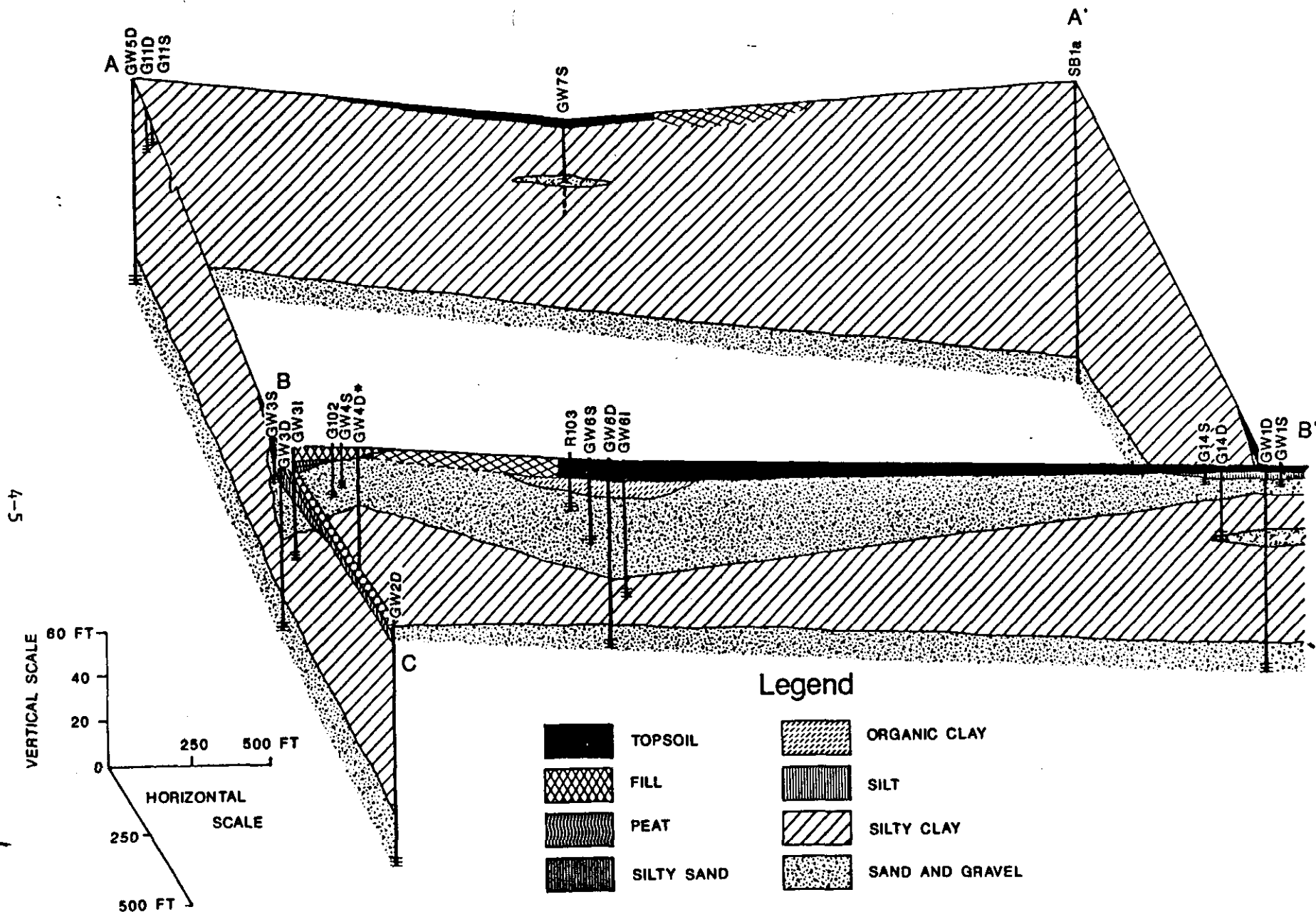
The upper sand unit consists of light brownish gray to dark gray fine- to medium-grained sand and small- to medium-sized pebbles. It is poorly to very poorly sorted and contains angular to rounded pebbles of



LEGEND

- FIT-CONDUCTED BORINGS (used to prepare fence and cross section diagrams)
- FIT-CONDUCTED BORINGS (not used to prepare fence and cross section diagrams)
- ◆ WMII-CONDUCTED BORINGS (not used to prepare fence and cross section diagrams)

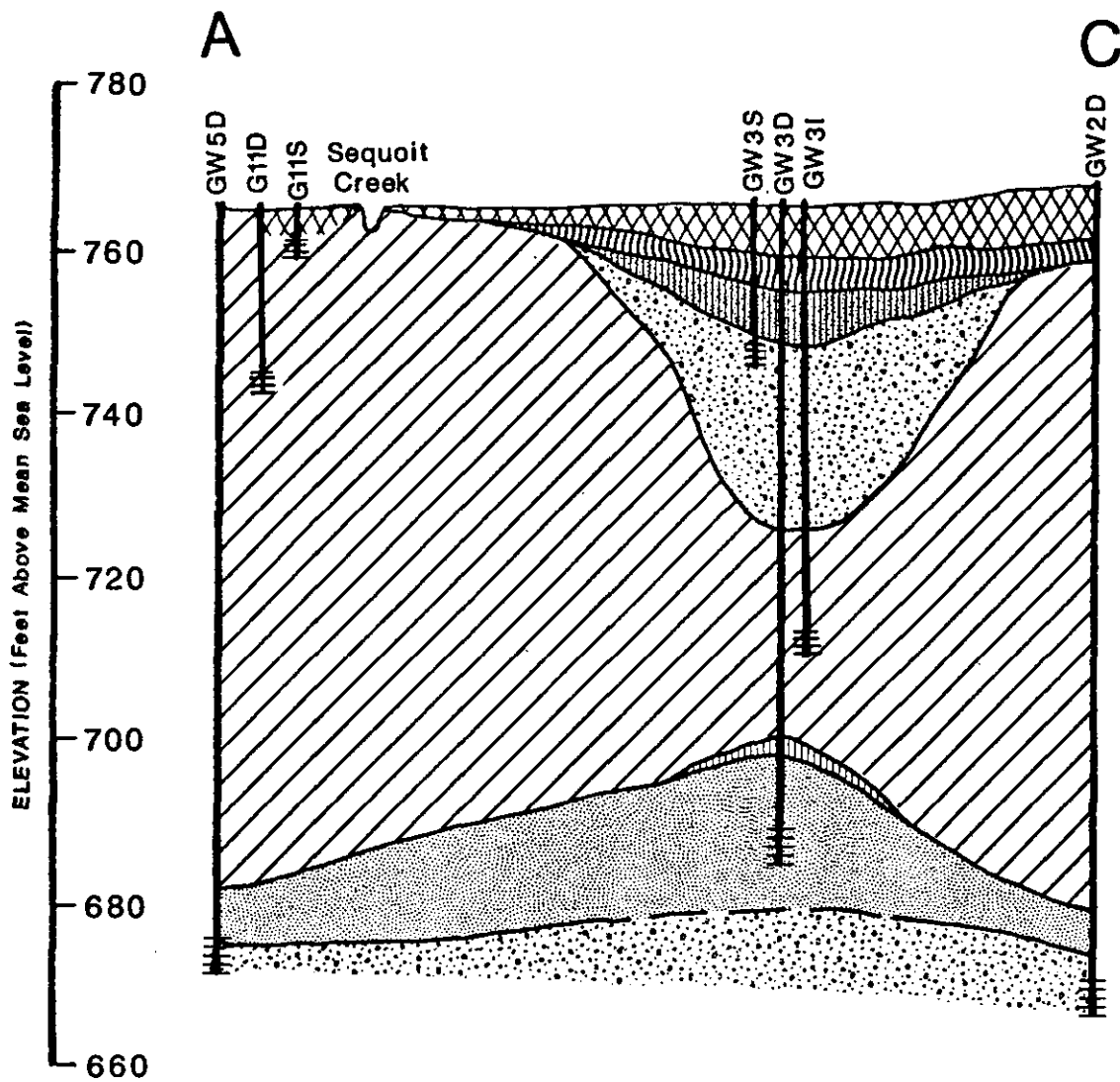
FIGURE 4-1 GENERALIZED CROSS SECTION LOCATIONS



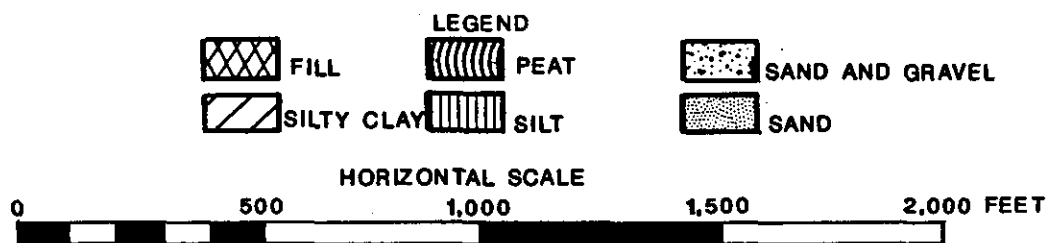
NOTE: Depictions of stratigraphy between borings are estimated.

*GW4D is screened in the lower sand and gravel
(well depth-approximately 104 feet; screen length-5 feet)

FIGURE 4-2 GENERALIZED FENCE DIAGRAM OF THE SITE AREA



SOURCE: Ecology and Environment, Inc. 1989.



NOTE: Depictions of stratigraphy between borings are estimated.

FIGURE 4-3 NORTH/SOUTH GENERALIZED CROSS SECTION (A-C)

mixed lithology. The upper sand and gravel deposit overlies the gray silty clay unit but is not continuous across the site.

The thickness of the lower sand and gravel at the site is not known but is at least 185 feet thick southwest of the site according to local water well logs of the area of the site. (Well logs of the area of the site are provided in Appendix B.) The upper portion of this lower unit consists primarily of medium- to coarse-grained sand with some fine-grained sand and pebbles. The deposit is moderately sorted and coarsens downward to form a poorly sorted sand and gravel deposit. The composition of the lower deposit is similar to the upper sand and gravel deposit.

A summary of the results of grain size distribution and falling head hydraulic conductivity tests conducted on FIT-collected soil samples is presented in Table 4-1. (Results of permeability and grain size analysis tests of FIT-collected subsurface soil samples are provided in Appendix D.)

Discussion. The unconsolidated deposits in the study area consist of a depositional sequence of till and outwash deposits associated with the Cahokia alluvium (Holocene) and Wadsworth Till Member of the Wedron Formation. The spatial and temporal occurrence of the deposits is shown in the fence diagram in Figure 4-2.

The unconsolidated deposits are divided into four distinct depositional units in decreasing age: a lower sand and gravel unit, a gray silty clay unit, an elongated upper sand and gravel unit, and surficial soils.

The lower sand and gravel unit is at least 185 feet thick southwest of the site, thins toward the north, and appears to be laterally extensive. The lower unit represents an outwash fan associated with Wedron glacio-fluvial deposition (Willman et al. 1975). The silty clay unit overlying the lower sand and gravel unit is also generally thick and laterally extensive. The color and texture of the silty clay unit is associated with till deposits of the Wadsworth Till Member (Johnson et al. 1985) and represents a readvancement of the Joliet Sublobe. The upper sand and gravel unit exhibits an elongated geometry and trends east/west along the southern boundary of the site. The upper unit is incised into the silty clay till unit and appears to be either a

Table 4-1

RESULTS OF PHYSICAL ANALYSIS OF PIT-COLLECTED SOIL SAMPLES

Boring Number	Soil Sample Depth (feet)	Approximate Grain Size Distribution (Percentage)					Hydraulic Conductivity (ft./sec.)*	
		Gravel	Coarse to Medium Sand	Fine Sand	Silt	Clay	Not Adjusted	Adjusted (to 20° C)
GW3I	49.5 to 51	0	2	8	24	66	—	—
GW3I	55 to 57.5	0	6	17	24	53	2.62×10^{-8}	2.30×10^{-8}
GW2D	19 to 21.5	0	13	25	44	18	1.42×10^{-6}	1.24×10^{-6}

* Originally reported in cm/sec.

— Hydraulic conductivity tests were not conducted for the sample from boring GW3I.

Source: Ecology and Environment, Inc. 1989.

Holocene (post-glacial) fluvial deposit emanating from a distant outwash fan. Isolated lenses of silty sand and organic-rich clay observed overlying the upper sand and gravel unit are representative of fine-grained, post-fluvial environments such as wetland or overbank deposits (Reineck and Singh 1980).

The surficial soils and peat deposits are representative of the Miami-Montmorenci and Morley-Markham-Houghton soil associations described by Paschke (1970).

4.2.2 Hydrogeology

The hydrogeology at the site was characterized by interpreting data gathered from static water level measurements, slug tests, and pump tests.

4.2.2.1 Sequoit Creek/Groundwater Interaction

Sequoit Creek/groundwater interaction was evaluated using water level measurements taken from FIT-installed streambed well points on November 13, 1987, and May 19, 1988.

Results. Distances to groundwater and Sequoit Creek surface water were measured from the tops of well points driven into the streambed of Sequoit Creek. Water elevations were calculated from these measurements and are presented in Table 4-2.

Discussion. Groundwater elevations were compared to surface water elevations for each of the streambed well points installed in Sequoit Creek. A groundwater elevation greater than the surface water elevation indicates an area of groundwater discharge. A groundwater elevation lower than the surface water elevation indicates a groundwater recharge area.

Water elevations calculated on November 13, 1987, indicate that groundwater was discharging to Sequoit Creek at WP1 and WP2. Water elevation data collected at WP3 indicates that Sequoit Creek was recharging the groundwater. However, the rate of groundwater infiltration into WP3 was extremely slow immediately following installation of the well point; therefore, the data are potentially unreliable. The groundwater infiltration rate into WP1 and WP2 was greater than the rate of WP3, and data from these well points is believed to be reliable.

Table 4-2

SEQUOIT CREEK WELL POINT WATER ELEVATIONS
(Feet Above Mean Sea Level)

Location	<u>11/13/87</u>		<u>5/19/88</u>	
	Groundwater	Surface Water	Groundwater	Surface Water
WP1	761.92	761.90	—	—
WP2	762.21	761.93	762.46	761.97
WP3	760.78	763.00	763.37	762.95

— Not recorded.

Source: Ecology and Environment, Inc. 1989.

Water elevation data collected on May 19, 1988, indicate that groundwater was discharging to Sequoit Creek at WP2 and WP3. Groundwater and surface water elevations were not calculated for WP1 on this date.

4.2.2.2 Static Groundwater Elevations

Depths to static groundwater were measured and recorded by FIT from FIT-installed monitoring wells periodically between August 1987 and May 1988. Also during this period, depths to groundwater of WMII wells were measured by GCL. Static groundwater elevations were calculated from these measurements and are summarized in Table 4-3.

Results. Potentiometric surface maps of the lower aquifer were prepared using static groundwater elevation data presented in Table 4-3. The potentiometric surface maps prepared from data collected on September 10, 1987, and October 28, 1987, illustrate typical groundwater flow patterns in the area of the site (see Figures 4-4 and 4-5, respectively). The potentiometric surface maps were used to determine groundwater flow direction and horizontal hydraulic gradients. Horizontal hydraulic gradients were calculated between wells most perpendicular to equipotential lines, and are presented in Table 4-4.

Shallow wells GW1S, GW3S, GW4S, and GW6S were installed in a linear pattern and are all screened in the same aquifer. Shallow well GW7S is located north of all other shallow wells but is not screened in the same hydrostratigraphic unit as the other shallow monitoring wells. This is evidenced by the differences in color and texture of the unconsolidated deposits encountered at boring GW7S as compared to the color and texture of the unconsolidated deposits at other boring locations (see well logs provided in Appendix C). Because of the alignment of the shallow monitoring wells, water table surface maps of the upper sand and gravel aquifer were not able to be developed. Static groundwater elevations were used to calculate horizontal hydraulic gradients of the upper sand and gravel aquifer between wells GW1S and GW6S, and GW6S and GW4S. Horizontal hydraulic gradients of the upper aquifer are presented in Table 4-5.

Discussion. Groundwater flow in the lower sand and gravel aquifer exhibited two distinctly different flow patterns, apparently influenced

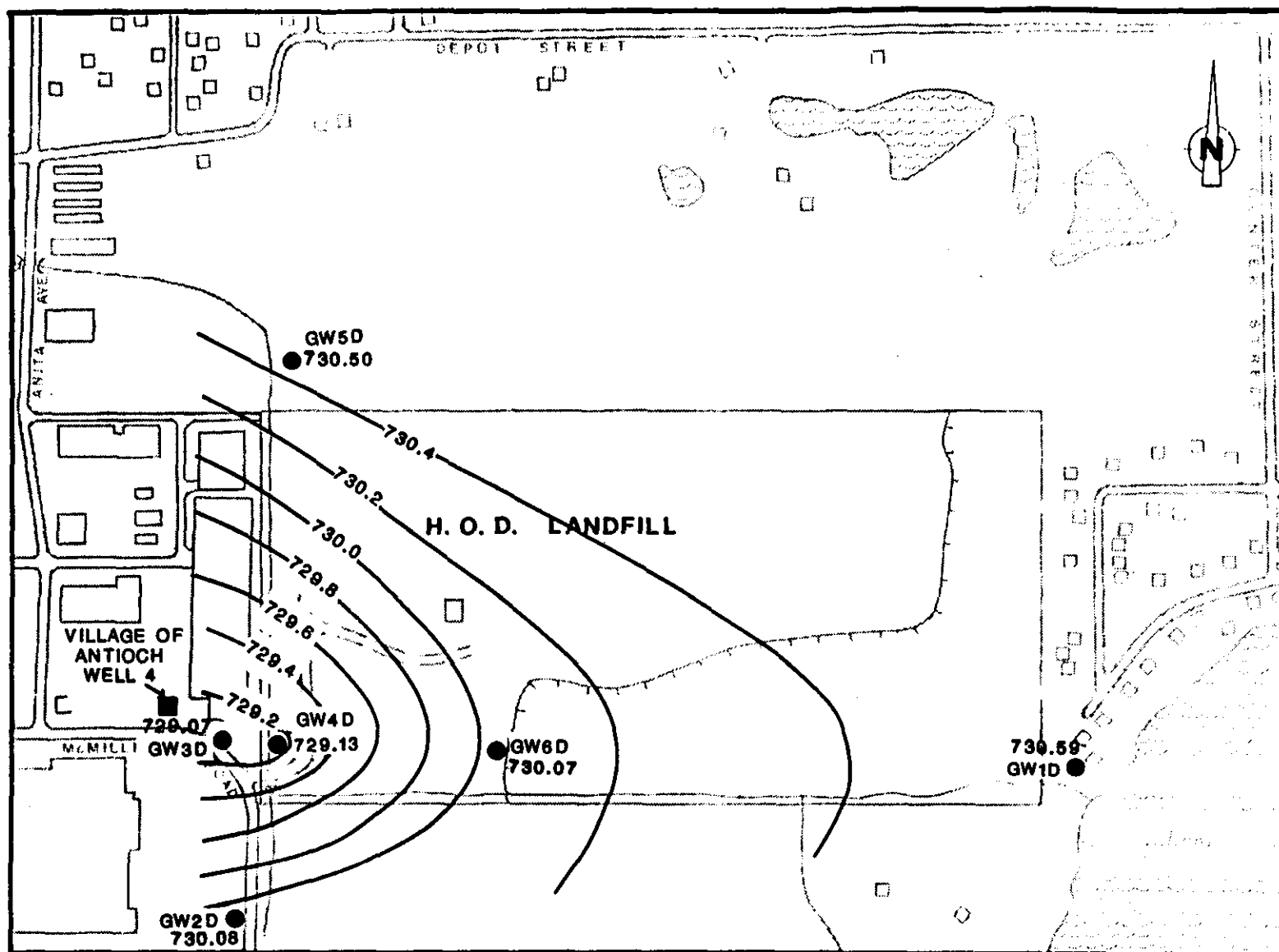
Table 4-3

STATIC GROUNDWATER ELEVATIONS
(Feet Above Mean Sea Level)

Well	08/03/87	08/12/87	09/10/87	09/21/87	09/23/87	10/28/87	11/13/87	04/18/88	05/19/88
GW1S	763.60	—	763.96	763.74	763.94	763.76	763.77	764.20	763.90
GW1D	729.98	—	730.59	730.93	730.43	730.29	730.35	731.86	730.86
GW2D	729.32	—	730.08	730.16	729.71	729.77	729.31	731.19	—
GW3S	761.40	—	762.10	762.80	762.11	762.17	762.21	762.81	762.30
GW3I	733.52	—	734.16	734.20	734.46	733.82	733.89	734.84	733.64
GW3D	729.03	—	729.07	730.77	730.34	730.36	728.26	731.71	730.12
GW4S	761.56	—	761.85	761.81	761.76	762.17	762.23	762.80	762.35
GW4D	729.11	—	729.13	730.58	730.20	730.07	728.62	731.24	730.21
GW5D	729.68	—	730.50	731.06	730.90	730.99	730.12	732.04	730.68
GW6S	761.96	—	762.63	762.55	762.62	762.65	762.64	763.17	762.75
GW6I	747.16	—	747.18	747.34	747.18	747.10	747.12	747.93	747.46
GW6D	729.77	—	730.07	730.70	730.33	730.21	729.60	731.72	730.59
GW7S	762.41	—	763.32	763.43	763.41	762.93	763.12	763.87	—
G11S	—	Dry	—	—	—	762.40	762.52	—	—
G11D	—	760.83	—	—	—	760.54	762.12	—	—
G102	—	761.13	—	—	—	762.13	762.22	762.67	762.22
R103	—	762.18	—	—	—	762.84	762.89	—	762.93
G14S	—	762.36	—	—	—	763.40	764.03	—	—
G14D	—	762.15	—	—	—	762.90	762.96	—	—

— Not recorded.

Source: Ecology and Environment, Inc. 1989.

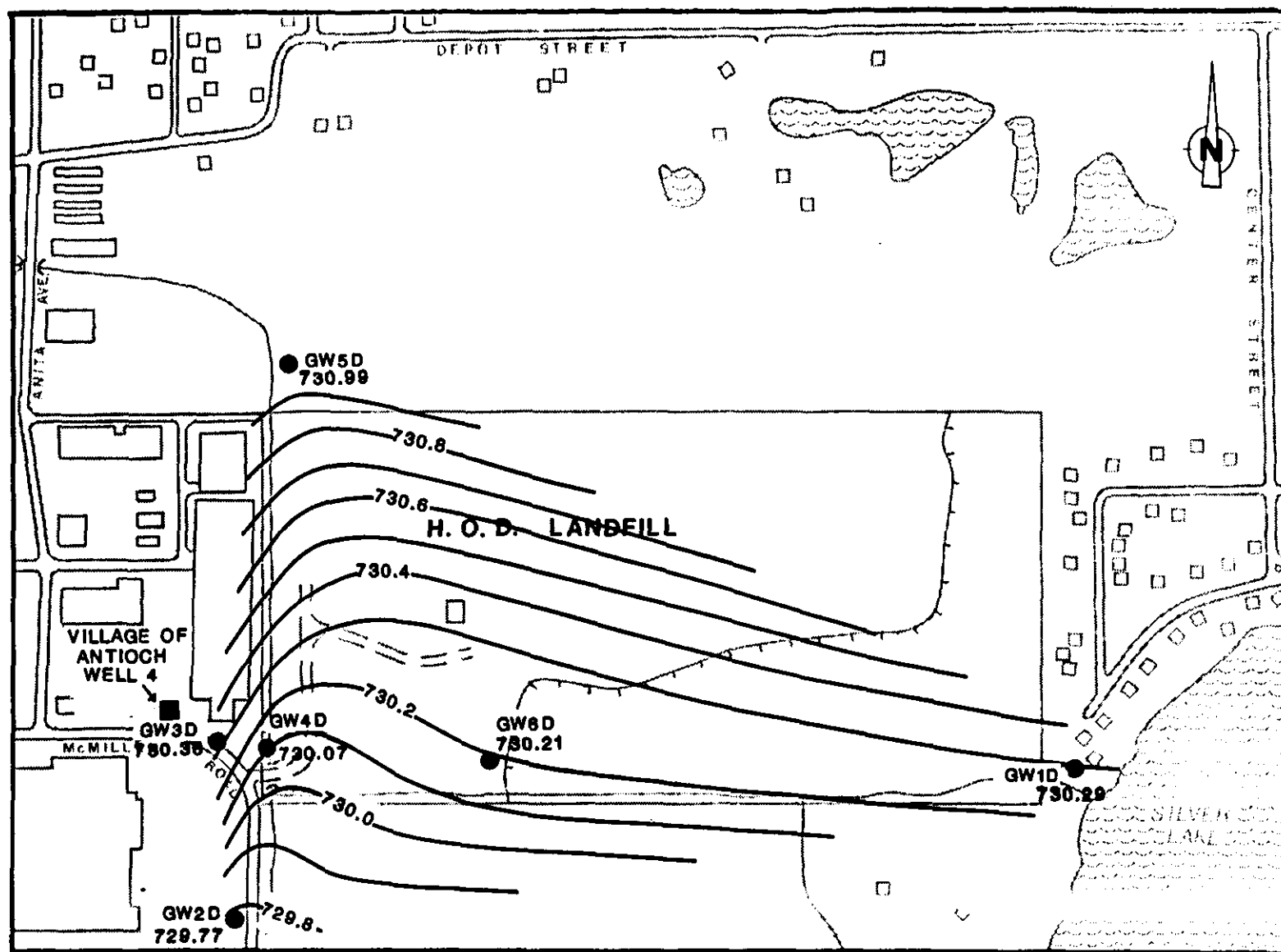


SOURCE: Ecology and Environment, Inc. 1989.

SCALE

0 500 1000 1500 2000 2500 FEET

FIGURE 4-4 POTENTIOMETRIC SURFACE MAP (September 10, 1987)



SOURCE: Ecology and Environment, Inc. 1989.

SCALE
0 500 1000 1500 2000 2500 FEET

FIGURE 4-5 POTENTIOMETRIC SURFACE MAP (October 28, 1987)

Table 4-4

HORIZONTAL HYDRAULIC GRADIENTS—LOWER AQUIFER

<u>Wells</u>		Groundwater Flow Direction	<u>Horizontal Hydraulic Gradient*</u>							
From	To		08/03/87	09/10/87	09/21/87	09/23/87	10/28/87	11/13/87	04/18/88	05/19/88
GW4D	GW3D	W	0.00042	0.00032	—	—	—	0.00189	—	0.00047
GW6D	GW4D	W	0.00014	0.00122	—	—	—	0.00127	—	0.00049
GW1D	GW6D	W	—	0.00026	—	—	—	0.00038	—	0.00014
GW6D	GW2D	SW	0.00042	—	—	—	0.00041	—	—	—
GW5D	GW4D	S	—	—	0.00037	0.00054	—	—	—	—
GW4D	GW2D	SSW	—	—	0.00070	0.00082	0.00050	—	—	—

* Horizontal hydraulic gradients were calculated using the static groundwater elevations presented in Table 4-3.

— Representative horizontal hydraulic gradients could not be calculated between these wells.

Source: Ecology and Environment, Inc. 1989.

Table 4-5

HORIZONTAL HYDRAULIC--UPPER AQUIFER

<u>Wells</u>		Groundwater Flow Direction	<u>Horizontal Hydraulic Gradient*</u>							
From	To		08/03/87	09/10/87	09/21/87	09/23/87	10/28/87	11/13/87	04/18/88	05/19/88
GW6S	GW4S	W	0.00052	0.00101	0.00103	0.00112	0.00062	0.00053	0.00048	0.00052
GW1S	GW6S	W	0.00083	0.00067	0.00060	0.00067	0.00056	0.00057	0.00052	0.00058

* Horizontal hydraulic gradients were calculated using the static groundwater elevations presented in Table 4-3.

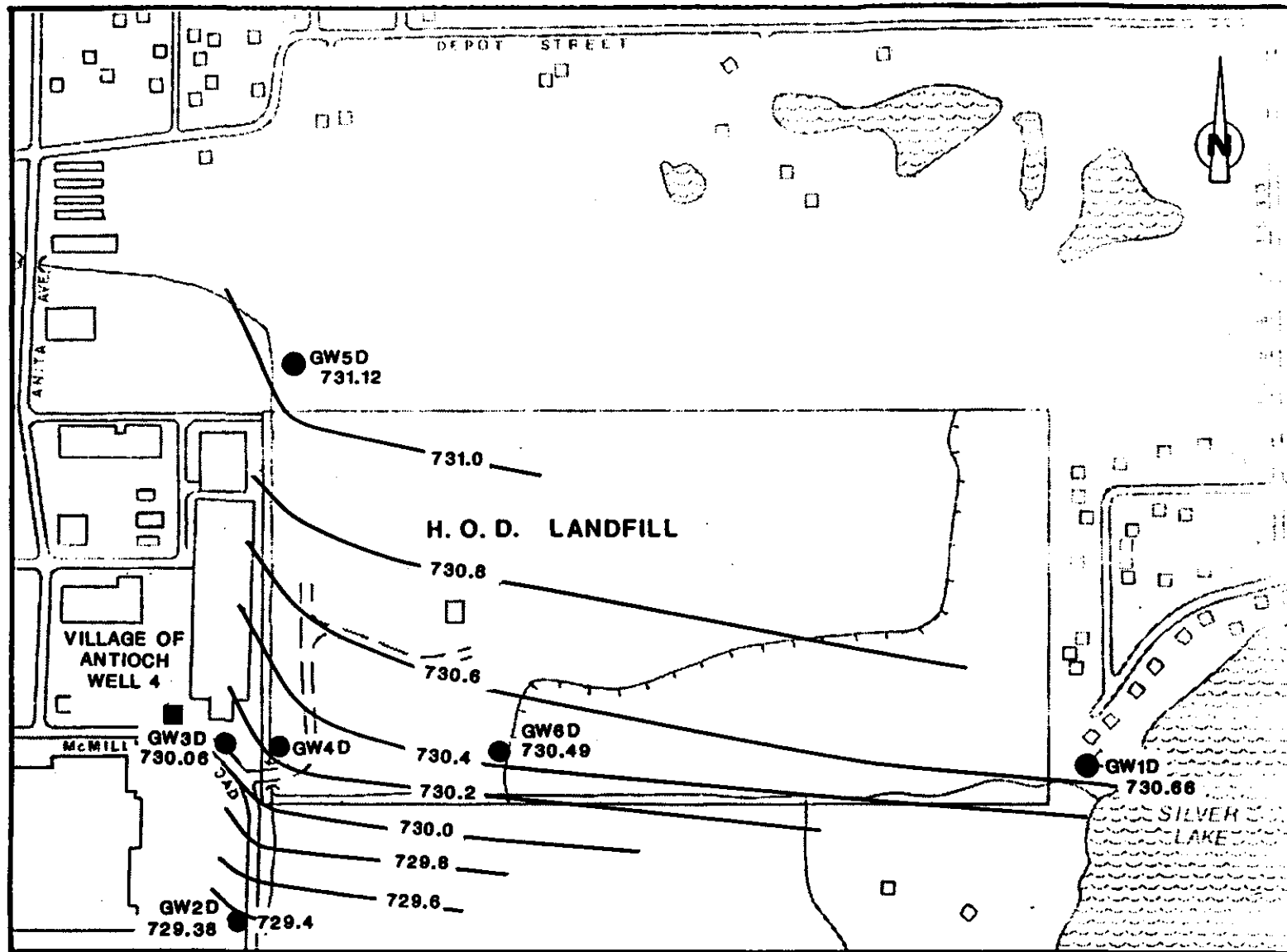
Source: Ecology and Environment, Inc. 1989.

primarily by the pumping of municipal wells 4 and 5. However, municipal well pumping data are not available for the dates on which static groundwater elevation data were recorded. Therefore, no direct correlation can be made between the pumping of the municipal wells (i.e., municipal well 4 or 5) and the groundwater flow patterns illustrated in Figures 4-4 and 4-5. However, municipal well pumping data are available for the dates during which the primary pump test was conducted. Potentiometric surface maps developed from groundwater level data recorded during the pump test (December 14 through December 19, 1987) show groundwater flow patterns similar to those depicted in Figures 4-4 and 4-5 and correlate to the municipal well pumping schedule.

The groundwater flow direction indicated in the potentiometric surface map prepared from groundwater elevation data recorded on December 15, 1987 (see Figure 4-6), is similar to that of the groundwater flow direction indicated in Figure 4-5. For approximately 36 hours prior to measuring groundwater elevations on December 15, 1987, municipal well 5, located approximately 1,600 feet south-southwest of the site, was the only municipal well pumping. The groundwater flow direction calculated from these groundwater elevations across the site was south-southwest, toward municipal well 5.

The groundwater flow direction indicated in the potentiometric surface map prepared from groundwater elevation data collected on December 17, 1987 (see Figure 4-7), is similar to that of the groundwater flow direction indicated in Figure 4-4. For approximately 12 hours prior to the collection of groundwater elevation data on December 17, 1987, municipal well 4 was the only municipal well pumping; also, municipal well 5 had been shut off for approximately 17 hours prior to the collection of the groundwater elevation data. Groundwater at the time of data collection (December 17, 1987) flowed radially across the site toward municipal well 4.

The municipal well pumping schedule was altered for conducting the primary pump test and is not what would normally be encountered in the routine operation of the municipal water supply system. Potentiometric surface maps prepared from data generated during the pump test, however, show the effects that the municipal water supply system, specifically



SOURCE: Ecology and Environment, Inc. 1989.



FIGURE 4-6 POTENTIOMETRIC SURFACE MAP (December 15, 1987)

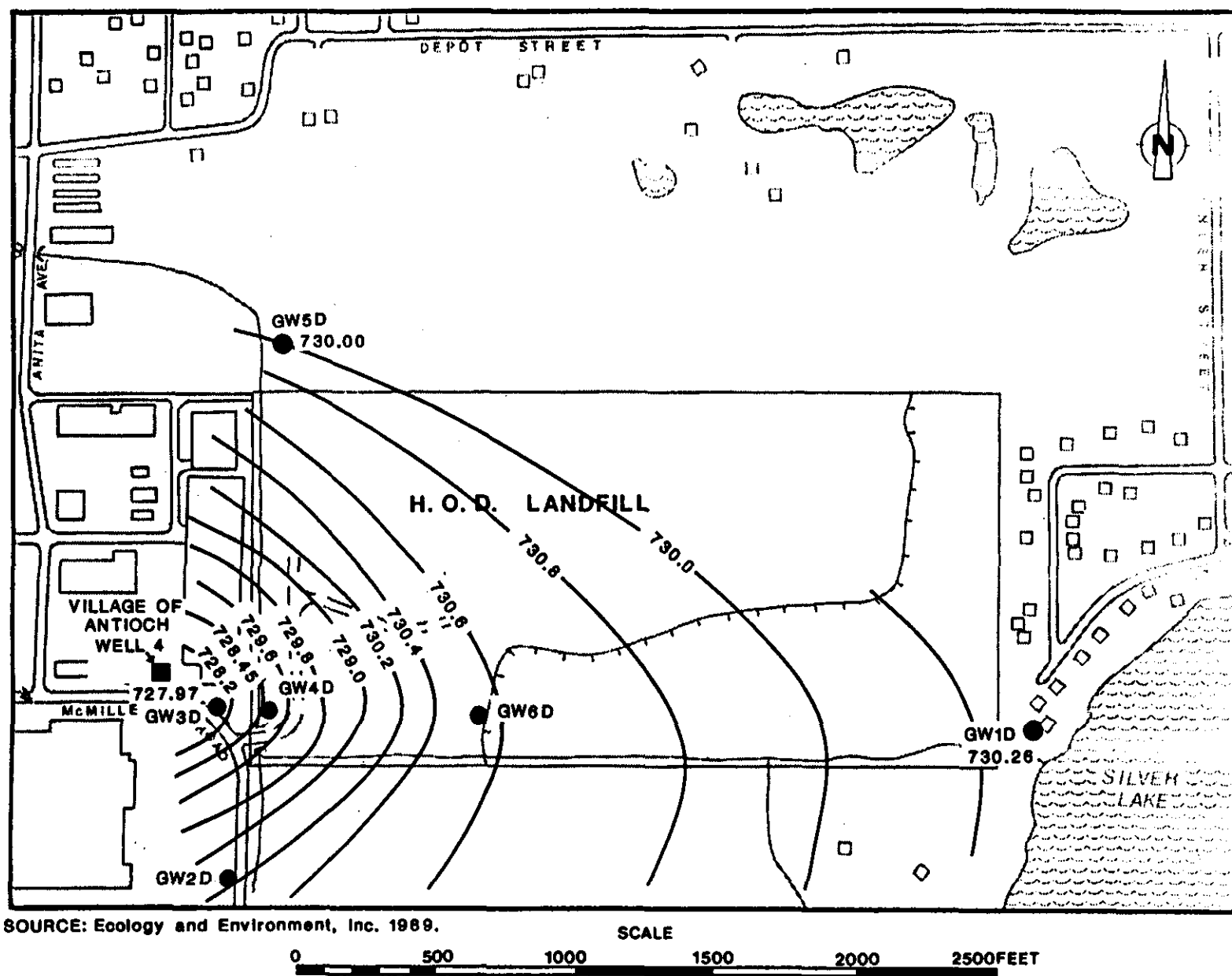


FIGURE 4-7 POTENTIOMETRIC SURFACE MAP (December 17, 1987)

the pumping of wells 4 and 5, has on the local groundwater flow patterns. Hydraulic gradients, groundwater velocities, and the extent of pumping influence were possibly exaggerated during the pump test, but the general groundwater flow directions were similar to the groundwater flow directions during routine operation of the system. During routine operating conditions, municipal wells 4 and 5 do not pump simultaneously. However, during periods of peak demand on the municipal system, the wells can pump simultaneously.

Lateral groundwater movement within the upper aquifer is restricted by the till in which it is situated. The upper sand and gravel aquifer appears to be oriented in an east/west direction along the southern boundary of the site.

Although a north/south component of flow possibly exists within the upper aquifer, only the east/west component of lateral flow was able to be calculated because of the alignment of the shallow monitoring wells. Therefore, for the purpose of calculating horizontal hydraulic gradients of the upper aquifer, the groundwater flow was assumed to be parallel to a line connecting the shallow monitoring wells along the gradient indicated by groundwater elevations. If existent, the north/south component of groundwater flow in the upper aquifer is expected to be minor relative to the east/west component, based on the physical restrictions of horizontal flow imposed by the less permeable till unit.

The horizontal hydraulic gradient of the upper aquifer was from east to west between monitoring wells GW1S and GW6S and between wells GW6S and GW4S for all dates that static groundwater elevations were calculated. The horizontal hydraulic gradients and groundwater flow directions between wells GW3S and GW4S cannot be conclusively determined because the wells are located on opposite sides of Sequoit Creek.

To define the groundwater flow patterns in the area between wells GW3S and GW4S, additional groundwater elevation points would be needed. However, a comparison of groundwater and surface water elevations at WP2 indicates an upward component of groundwater flow at the well point location. The lateral groundwater flow within the upper aquifer across the site is from east to west. Groundwater flow in the upper aquifer near wells GW3S and GW4S is most likely toward Sequoit Creek.

The relationship between the large wetland south of the site and the upper aquifer was not able to be determined because no groundwater monitoring wells are located in the wetland and therefore, comparative groundwater elevation data were not available. Surface water of the wetland does, however, drain north and west into Sequoit Creek at the southwestern corner of the site. Although vertical hydraulic gradients were not calculated because the exact screen intervals of WMII wells are not known, vertical flow directions between paired monitoring wells screened at different elevations within the upper aquifer were determined by comparing groundwater elevations to relative well screen depths. The vertical component of groundwater flow at each of these well pairs (G11S/G11D, GW4S/G102, R103/GW6S, and G14S/G14D) was downward based on groundwater elevation data presented in Table 4-3.

4.2.2.3 Horizontal Hydraulic Conductivities

Horizontal hydraulic conductivities were calculated for the upper and lower upper aquifers and the Wadsworth Till using data gathered during slug tests of FIT-installed wells conducted by FIT on September 10 and 11, 1987, and September 24, 1987.

Results. Slug test data from the shallow and intermediate depth wells were analyzed using the Hvorslev method. The equation used to calculate horizontal hydraulic conductivities assumes the following conditions: 1) the aquifer is unconfined, 2) the well is of a small diameter, and 3) the length of the screen is small relative to the total length of the well pipe (Freeze and Cherry 1979). The shallow and intermediate wells are screened in unconfined deposits, are constructed of 2-inch ID well pipe, and have well screens that are 5 feet and 3 feet in length, respectively, thus meeting the assumptions of the Hvorslev method. Slug test data were used to calculate the horizontal hydraulic conductivities of aquifer materials adjacent to the well screens. Slug test horizontal hydraulic conductivity values ranged from 2.30×10^{-3} ft./sec. to 1.59×10^{-5} ft./sec. for the upper aquifer, with an average horizontal hydraulic conductivity of 1.02×10^{-3} ft./sec. Horizontal hydraulic conductivities of the Wadsworth Till were calculated to be 2.60×10^{-7} ft./sec. and 2.62×10^{-7} ft./sec. at wells GW3I and GW6I, respectively.

Slug test data from the lower confined aquifer wells were analyzed by a technique described by Cooper. The Cooper technique assumes the following: 1) the aquifer is confined, 2) confining units above and below the aquifer are impermeable, and 3) the well is screened the full length of the aquifer (Cooper, Bredehoeft, and Papadopolous 1967). Slug test data were used to determine transmissivity (T) and storativity (S). Horizontal hydraulic conductivity (K) was then calculated using the equation $T = Kb$, where b equals the aquifer thickness. Because the thickness of the aquifer is unknown and only a small portion of it is screened, the screen length was used as the b value. Horizontal hydraulic conductivities of the lower aquifer approximated by the Cooper technique ranged from 5.20×10^{-4} ft./sec. to 3.54×10^{-5} ft./sec. The average horizontal hydraulic conductivity of the lower aquifer is 1.99×10^{-4} ft./sec. A summary of the slug test analysis is presented in Table 4-6. (Results of the slug test analysis of FIT-installed monitoring wells are provided in Appendix E.)

Discussion. The horizontal hydraulic conductivities presented in Table 4-6 represent the horizontal hydraulic conductivity of the aquifer materials at the screened interval of each well. The horizontal hydraulic conductivity values calculated from the slug test data correspond to hydraulic conductivity values presented by Freeze and Cherry (1979) for similar aquifer materials as those present at the site.

Horizontal hydraulic conductivity values of the upper aquifer were calculated using the Hvorslev method. The conductivity of well GW1S is approximately two orders of magnitude less than the average conductivity of the shallow wells, indicative of the higher silt content visually observed in soil samples collected from the screened zone of well GW1S. Horizontal hydraulic conductivities of all other shallow wells were within one order of magnitude of each other.

Horizontal hydraulic conductivities of the intermediate-depth wells were also calculated using the Hvorslev method; however, the slug test data of well GW3S were obtained by conducting a falling head slug test. A falling head slug test was deemed necessary because of the slow recharge rate of the well. The horizontal hydraulic conductivity values of the two intermediate wells (GW3I and GW6I) are nearly identical to each other. The laboratory-conducted falling head hydraulic

Table 4-6

SUMMARY OF SLUG TEST ANALYSIS

Well	Conductivity (ft./sec.) (Hvorslev Method)	Transmissivity (T) (ft. ² /sec.) (Cooper Method)	Conductivity (K) (ft./sec.) (T = Kb; b = screen length)
GW1S	1.59×10^{-5}	--	--
GW1D	--	2.96×10^{-4}	5.92×10^{-5}
GW2D	--	2.08×10^{-3}	4.16×10^{-4}
GW3S	8.76×10^{-4}	--	--
GW3I	2.60×10^{-7}	--	--
GW3D	--	5.15×10^{-4}	1.03×10^{-4}
GW4S	1.74×10^{-3}	--	--
GW4D	--	1.77×10^{-4}	3.54×10^{-5}
GW5D	--	2.60×10^{-3}	5.20×10^{-4}
GW6S	2.30×10^{-3}	--	--
GW6I	2.62×10^{-7}	--	--
GW6D	--	3.03×10^{-4}	6.06×10^{-5}
GW7S	1.89×10^{-4}	--	--

-- Analytical results were not obtained using this method.

Source: Ecology and Environment, Inc. 1989.

conductivity test result of a sample collected from the screened interval of well GW3I is also within one order of magnitude of the slug test-calculated value.

Horizontal hydraulic conductivities of the lower aquifer were calculated using the Cooper technique and are within approximately one order of magnitude of each other. However, these values are considered only approximations. All the assumptions of the Cooper technique were not met. Specifically, the monitoring wells do not fully penetrate the aquifer and the permeabilities of the units above and below the aquifer are not known.

A source of error for calculating the horizontal hydraulic conductivities exists if the filter pack surrounding the monitoring well screen has a significantly higher hydraulic conductivity than the geologic formation in which it is situated; horizontal hydraulic conductivities of the aquifer calculated from the slug test data may be biased high where this condition exists.

A comparison of the horizontal hydraulic conductivities revealed higher values for the upper aquifer compared to the lower aquifer. The average horizontal hydraulic conductivity of the upper aquifer is approximately one order of magnitude greater than that of the lower aquifer, indicative of the greater gravel content in the upper unit. The horizontal hydraulic conductivities of the Wadsworth Till, located between the aquifers at wells GW3I and GW6I, are four orders of magnitude less than the average horizontal hydraulic conductivity of the upper aquifer.

4.2.2.4 Horizontal Groundwater Velocities

Horizontal hydraulic conductivity values and horizontal hydraulic gradient values were used to calculate horizontal groundwater velocities of the upper and lower aquifers.

Results. The average linear groundwater velocities (V) were calculated using Darcy's equation and are presented in Table 4-7; to calculate laminar flow in saturated conditions, the following equation was used:

Table 4-7

HORIZONTAL GROUNDWATER VELOCITIES

Aquifer	Lower						Upper	
Groundwater Flow Direction	West				South-Southwest		West	
Gradient	From GW1D to GW3D		From GW6D to GW3D		From GW4D to GW2D		From GW1S to GW4S	
Range	Low	High	Low	High	Low	High	Low	High
K (ft./sec.)	1.99×10^{-4}	1.99×10^{-4}	1.99×10^{-4}	1.99×10^{-4}	1.99×10^{-4}	1.99×10^{-4}	1.02×10^{-3}	1.02×10^{-3}
dh/dl	.00025	.00070	.00049	.00140	.00050	.00082	.00051	.00079
NE	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
V (ft./day)	1.72×10^{-2}	4.81×10^{-2}	3.37×10^{-2}	9.63×10^{-2}	3.44×10^{-2}	5.64×10^{-2}	1.80×10^{-1}	2.78×10^{-1}
V (ft./yr.)	6.28	17.57	12.30	35.14	12.55	20.58	65.62	101.65

Source: Ecology and Environment, Inc. 1989.

$$V = K \times \frac{dh}{dl} \times \frac{1}{NE},$$

Where: K = horizontal hydraulic conductivity,

$\frac{dh}{dl}$ = horizontal hydraulic gradient, and

NE = effective porosity.

The averages of the horizontal hydraulic conductivity values calculated from slug test data of monitoring wells in each aquifer were used in calculating the horizontal groundwater velocities.

Horizontal hydraulic gradients were calculated from static groundwater elevations. Two gradients (the highest and lowest) were used for the upper aquifer to provide a range of groundwater velocities that would be expected to occur in the vicinity of the site. Several gradients were used in calculating the velocities for each flow pattern common to the lower aquifer.

Effective porosity refers to the amount of interconnected pore space available for fluid flow and is expressed as a ratio of interstices to total volume. For unconsolidated porous media and for many consolidated rocks, the two porosities are identical (Todd 1959). Values of porosity for sand range from 0.25 to 0.50 (Freeze and Cherry 1979). By using the lower value of the range of porosities (0.25) in the velocity equation, the maximum expected velocities were calculated.

Discussion. The horizontal hydraulic gradients calculated for the upper and lower aquifers were variable over time and were calculated using static groundwater elevation data. Groundwater velocities were calculated for each of the dates on which static groundwater measurements were recorded.

The velocities calculated for the upper aquifer ranged from 65.62 ft./yr. to 101.65 ft./yr. Each groundwater velocity calculation of the upper aquifer represents the average horizontal groundwater velocity along the entire southern boundary of the landfill, between monitoring wells GW1S and GW4S.

The following two distinct patterns of groundwater flow were observed in the lower aquifer.

- A south-southwesterly groundwater flow direction across the site occurs when municipal well 5 is pumping. The groundwater velocities of the lower aquifer in the vicinity of the site were calculated between monitoring wells GW4D and GW2D when a south-southwesterly flow direction was observed. These groundwater velocities ranged from 12.55 ft./yr. to 20.58 ft./yr.
- Radial groundwater flow across the site toward municipal well 4 occurs when municipal well 4 is pumping. According to Darcy's equation, the horizontal component of the groundwater velocity is a function of the horizontal component of the hydraulic gradient. When well 4 is pumping, the horizontal component of the hydraulic gradient is greatest near municipal well 4 and decreases away from it. This change of the magnitude of the horizontal component of the hydraulic gradient is significant because of the proximity of municipal well 4 to the site and the length of the site. Therefore, velocities were calculated between monitoring wells GW1D and GW3D to obtain a range of average velocities across the entire site, and between monitoring wells GW6D and GW3D, to emphasize the increase of average groundwater velocities as the distance to municipal well 4 became less. The average groundwater velocities across the entire site (GW1D to GW3D) ranged from 6.28 ft./yr. to 17.57 ft./yr. The average groundwater velocities across the western portion of the site (GW6D to GW3D) ranged from 12.30 ft./yr. to 35.14 ft./yr.

4.2.2.5 Preliminary Pump Test

A preliminary pump test was conducted jointly by U.S. EPA, FIT, and USGS to determine the effect pumping a well screened in the lower aquifer (municipal well 4) had on the drawdown characteristics of the

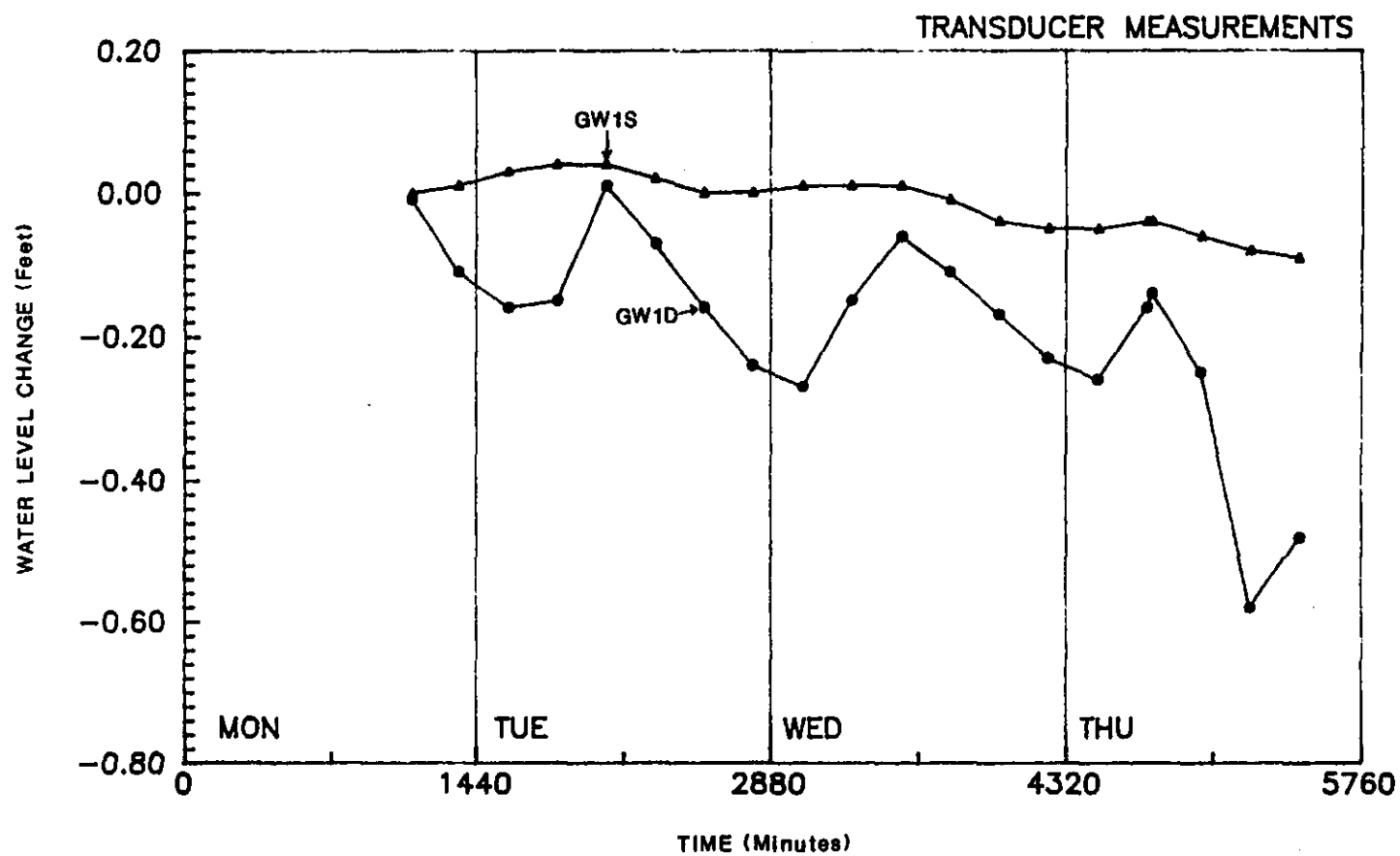
upper and lower aquifers and the Wadsworth Till. The preliminary pump test was also used to determine appropriate monitoring wells to use for the primary pump test, and to determine the appropriate durations of the primary pump test and recovery test. Monitoring wells GW1S, GW1D, GW2D, GW3S, GW3I, GW3D, and GW4D were chosen as observation wells for conducting the preliminary pump test.

4.2.2.5.1 Results

A graph depicting water levels for wells GW1S and GW1D, recorded during the week of September 24, 1987, is presented in Figure 4-8. (Data used to prepare the graph are provided in Appendix F.) (Water levels for wells GW2D, GW3S, GW3I, GW3D, and GW4D recorded during the 12 hours preceding the pump test and water levels recorded during the pump test at all observation wells are also presented in Appendix F.)

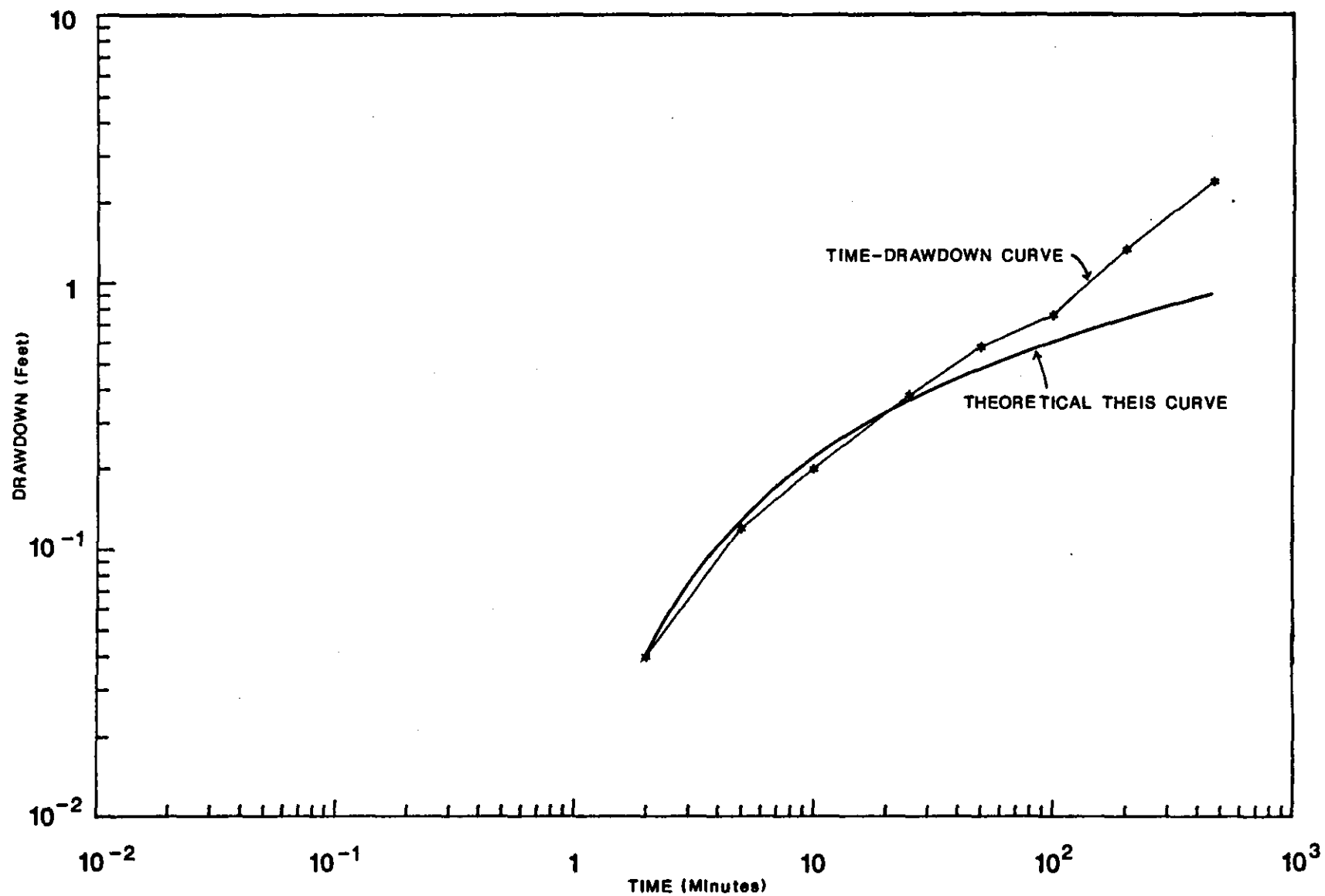
4.2.2.5.2 Interpretation

A time-drawdown curve was prepared for observation well GW2D (see Figure 4-9). Because data from the initial 25 minutes of the test were not gathered, data from the first 25 minutes of the recovery test were substituted, as was suggested by USGS. Wells GW3S and GW3I were not used in the time-drawdown analysis because they were not screened in the pumped aquifer. Wells GW3D and GW4D were not used in the analysis because of partial penetration concerns. Partial penetration describes a situation where the pumping well is not screened throughout the entire thickness of the aquifer. When the pumping well is partially penetrating, radial flow to an observation well is distorted, violating a major assumption (radial flow) of aquifer test analysis methods, which results in distorted drawdown data. Partial penetration effects on drawdown at observation wells, however, decrease with increased radial distance from the pumping well. At observation wells greater than 1 1/2 times the distance of the aquifer thickness from the pumping well, the partial penetration effects on drawdown are negligible and can be disregarded (Hantush 1961). For the preliminary pump test, a conservative estimate of three times the thickness of the aquifer was used. Municipal well 4 partially penetrates the lower aquifer, which is approximately 150 feet thick in the vicinity of the site. Well GW2D is located at a distance



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 4-8 WATER LEVELS OF MONITORING WELLS GW1S AND GW1D -- TRANSDUCER MEASUREMENTS
(September 21 Through 24, 1987)



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 4-9 TIME-DRAWDOWN CURVE FOR MONITORING WELL GW2D (September 24, 1987)

greater than three times the thickness of the aquifer from the pumping well (approximately 750 feet). Wells GW1S and GW1D are also located at a distance greater than three times the thickness of the aquifer from the pumping well (approximately 3,460 feet).

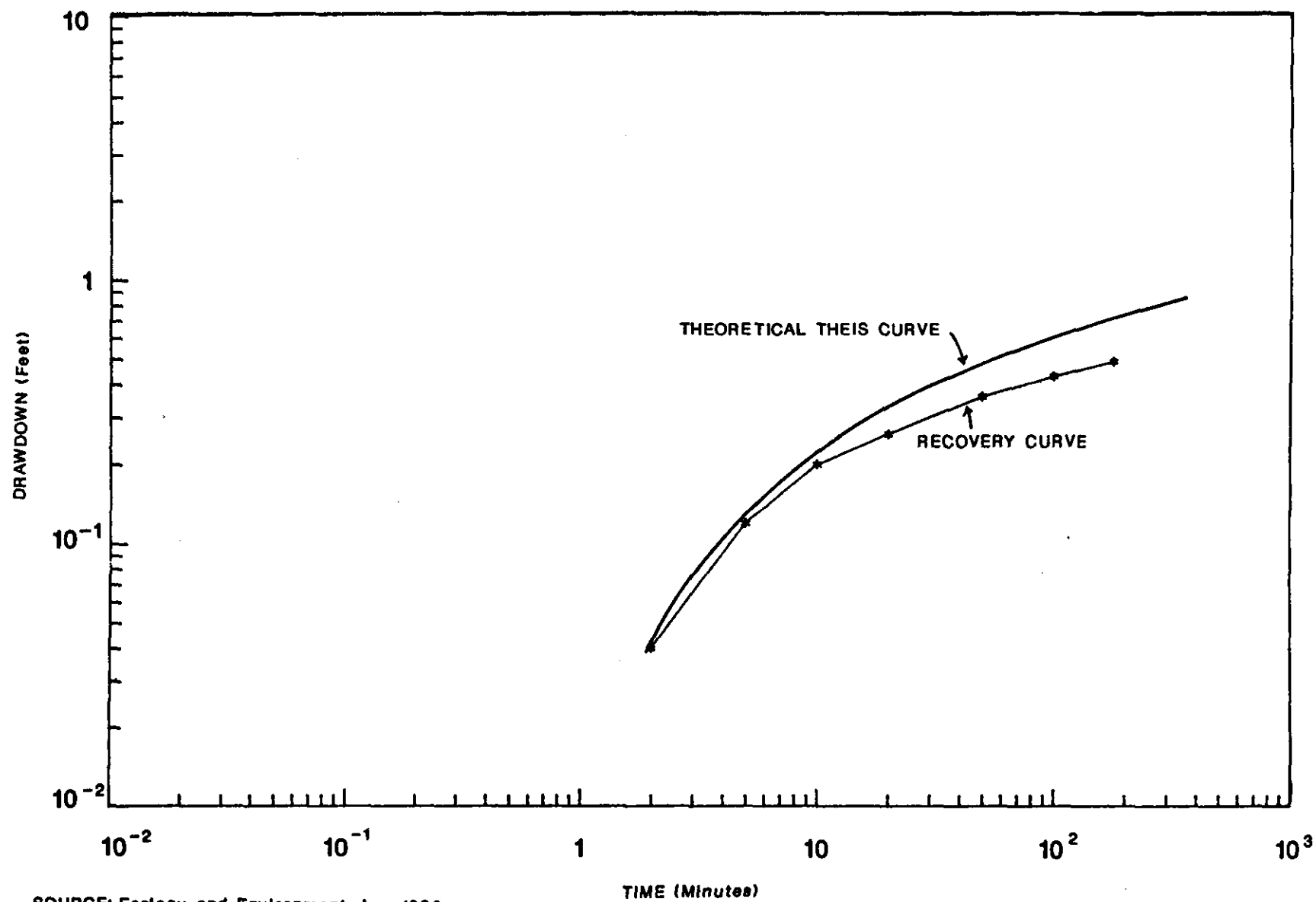
4.2.2.5.3 Discussion

The two curves of Figure 4-8 depicting water level changes at GW1S and GW1D during the week of September 24, 1987, show similar patterns of water level changes. However, the changes are less pronounced in GW1S than in GW1D. The similar patterns observed in both wells indicate that the upper and lower aquifers are responding similarly to an unknown stress, possibly nearby residential and municipal well pumping or phreatic stresses. If it could be demonstrated that the aquifers are responding similarly to pumping, then it could be assumed that the aquifers are hydraulically connected. Concurrent data are unavailable, however, regarding well pumping and phreatic stresses in the area of GW1S and GW1D.

The time-drawdown curve prepared for well GW2D exhibits a barrier boundary effect (see Figure 4-9). This effect is shown on the graph where the drawdown rate exceeds that of the Theis theoretical curve. The Theis curve indicates time-drawdown rates for an aquifer that is confined, homogeneous, isotropic, of uniform thickness, and of infinite areal extent. This deviation is assumed to be the result of the pumping of municipal well 5 (located 1,000 feet southwest of GW2D) and adding to the drawdown at well GW2D. The deviation occurred at approximately $t = 280$ minutes, which is the approximate time when municipal well 5 is believed to have been activated.

The recovery curve prepared for well GW2D indicates an incomplete water level recovery in well GW2D (see Figure 4-10). The water level at the end of the recovery test (which lasted 6.7 hours) was approximately 2 feet lower than at the start of the pump test. The pumping of municipal well 5 is believed to have caused the limited recovery.

Because of the limited recovery and probable sporadic pumping of municipal well 5 during the preliminary pump test, the recovery data recorded during the initial 25 minutes of the test used in the drawdown analysis are not reliable. This data is most likely affected by draw-



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 4-10 RECOVERY CURVE FOR MONITORING WELL GW2D (September 24, 1987)

down caused by the pumping of municipal well 5; therefore, no conclusions were able to be made from the drawdown and recovery test data regarding aquifer parameters (e.g., transmissivity and storativity) and the hydraulic connection of the aquifers. However, the preliminary pump test provided information necessary for conducting the primary pump test.

4.2.2.6 Primary Pump Test

A primary pump test was conducted jointly by U.S. EPA, FIT, and USGS to determine the effectiveness of the Wadsworth Till as a potential confining unit. Monitoring wells GW1S, GW1D, GW2D, GW3S, GW3I, GW3D, GW4D, GW6S, GW6D, and WMII well G102 were chosen as observation wells for conducting the primary pump test.

4.2.2.6.1 Results

Results of the FIT-conducted pre-pump test, pump test, and recovery test are presented as follow.

Pre-Pump Test. Water levels recorded during the week of December 19, 1987 (measured with a steel tape and an electric water level indicator), are summarized in a table provided in Appendix F. (Corresponding graphs depicting the water levels measured in each monitoring well were also prepared and are provided in Appendix F with preliminary and primary pump test data, hydrogeological calculations, ancillary data, and a complete record and figure depicting municipal well pumping times).

Pump Test. The 24-hour drawdown data, corrected for barometric fluctuation, are provided in a table in Appendix F. A barometric efficiency of the lower aquifer was assumed to be 50%, a reasonable estimate for a sand and gravel aquifer (Kay 1988). The corrections were made according to Walton (1962). Barometric correction factors were assigned for every 0.5 millibar (mb) fluctuation during the drawdown. (A 1 mb change in barometric pressure equals a 0.016 foot change in water level.) The barometric corrections are summarized in a table provided in Appendix F. Complete drawdown and barometric data are also provided in Appendix F. Drawdown was measured in all deep wells from 0.41 feet at well GW1D, to 3.01 feet at GW3D. Drawdown in the shallow wells was not significant (GW3S, 0.022 feet; G102 [WMII], 0.00 feet; GW1S, 0.00

feet). Significant drawdown was measured in the intermediate-depth wells (GW6I, 0.12 feet and GW3I, 0.67 feet). The data for the intermediate wells were corrected for barometric fluctuations.

Recovery Test. Data collected during the 24-hour recovery test are provided in Appendix F. No summary table or data curves were constructed because of complexities caused by the pumping of well 5, which occurred 12 minutes into the recovery test. After municipal well 4 was turned off, municipal well 5 began pumping and continued pumping for 13 hours (see the table of the municipal well pumping schedule provided in Appendix F).

4.2.2.6.2 Interpretation Methods

Several interpretative methods for evaluating pump test data were used to characterize the site hydrogeology. Time-drawdown curves were prepared to determine the lower aquifer's response to pumping. Recharge effects evident in the time-drawdown curves dictated what subsequent analysis methods could be used. To determine whether a recharge boundary was located in the area, image well analyses were conducted according to Walton (1962) and Moulder (1963). Also, to determine whether recharge effects observed in the time-drawdown curves were caused by a recharge boundary or leakage, a distance-drawdown analysis (Driscoll 1986) was conducted. Assuming leakage was the cause of the recharge, aquifer hydraulic characteristics were determined using the Hantush-Jacob method as described by Lohman (1979), and aquitard characteristics were determined by the ratio method (Neuman and Witherspoon 1972).

Time-Drawdown Curves. To determine whether the aquifer of concern responded to pumping as an ideal aquifer, time-drawdown curves were prepared. The preparation of the curves consisted of plotting time versus drawdown on a logarithmic graph and comparing the curve to theoretical curves generated for ideal aquifers. Deviations from the theoretical curves indicated whether aquifer conditions such as leaky aquifers or impermeable boundaries were present. Time-drawdown curves were prepared for wells GW1D, GW2D, and GW6D; drawdown data from wells GW3D and GW4D were not used in the analysis because of the two wells' proximity to the pumping well, which causes distortions of the time-

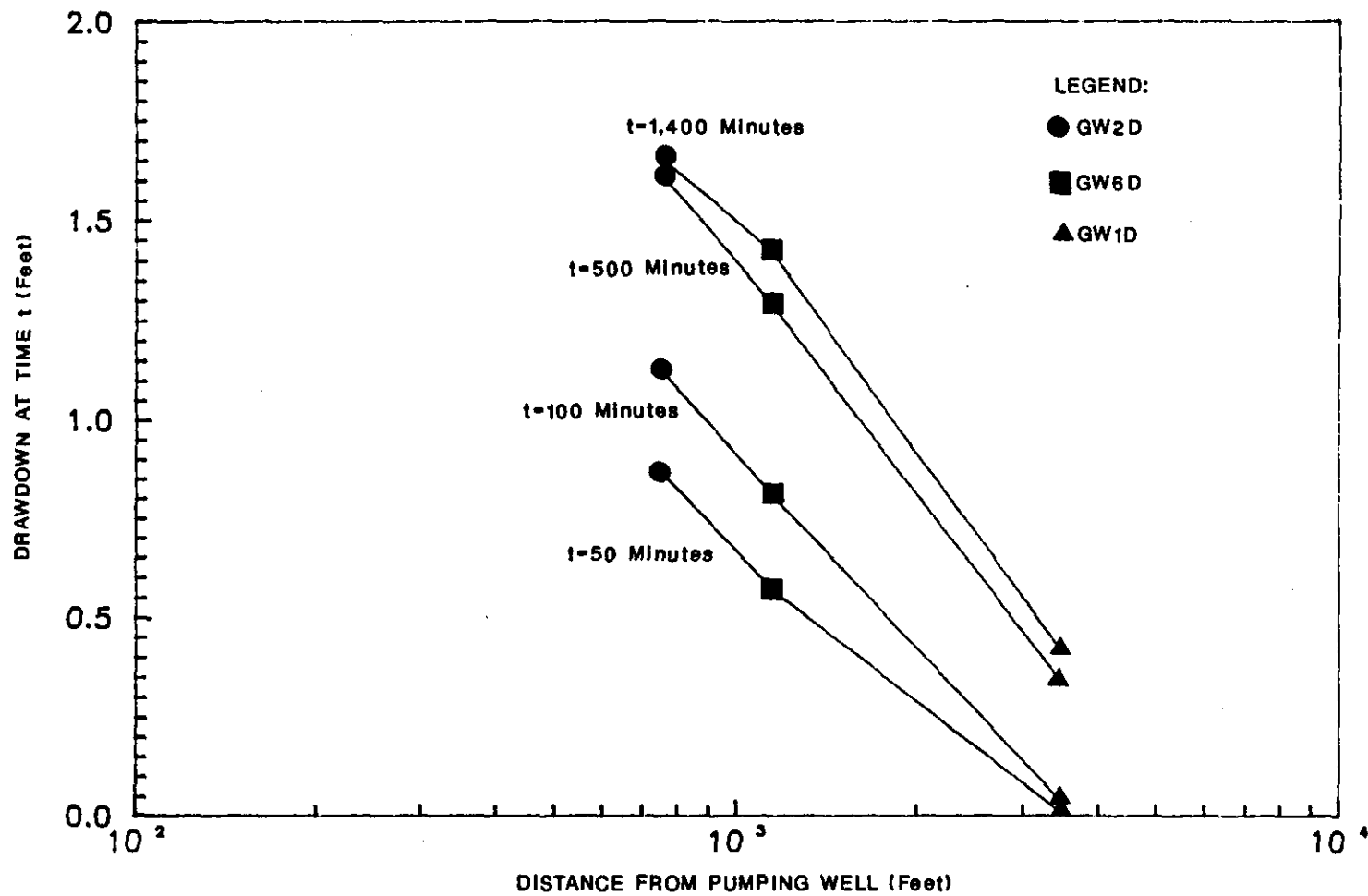
drawdown curves (figures of the time-drawdown curves for wells GW1D, GW2D, and GW6D have been prepared and are provided in Appendix F).

Image Well Analysis. To determine whether the recharge effects on the pumped aquifer indicated by the time-drawdown and distance-drawdown curves were caused by leakage from semi-confining units or some other factor (e.g., surface water bodies), two methods of image well analysis were conducted. The first method used was the law of times, as described by Walton (1962). This method involves drawing three circles on a map of the site area, each centered at a different observation well. The radii of the circles were determined according to a relation known as the law of times, which is a relation involving drawdown at an observation well and the observation well's distance from the pumping well. The points of intersection of the circle arcs on the map indicate the location of hydraulic boundaries.

The second method of image well analysis used by FIT was developed by Moulder (1963). It was developed for use in cases where pump test data are available from only one or two observation wells. The method uses geometric relations between the discharge and observation wells, and the image well circle radius determined from the law of times. The end result of the method is a circle which is a locus of all possible boundary locations. Two analyses were conducted using this method: one for well GW1D, and one for GW2D.

Distance-Drawdown Curves. A distance-drawdown analysis was conducted using data from wells GW1D, GW2D, and GW6D to determine whether recharge effects were present during the pump test. The method used by FIT involved plotting the drawdown values from a series of observation wells at a particular time during the pump test versus the corresponding distance of each observation well from the pumping well. Deviations from a straight line connecting the points indicate possible boundary conditions, either recharge or barrier. Four distance-drawdown curves were prepared to illustrate aquifer boundary conditions at different times during the pump test (see Figure 4-11). Data used to prepare Figure 4-11 are provided in Appendix F.

Hantush-Jacob Method. Assuming the deviation of the time-drawdown curves from the theoretical curve was caused by leakage from an adjacent unit, the Hantush-Jacob method was used to determine aquifer storativity



SOURCE: Ecology and Environment, Inc. 1989.

FIGURE 4-11 DISTANCE-DRAWDOWN CURVES FOR MONITORING WELLS GW1D, GW2D, AND GW6D
(December 17 and 18, 1987)

and transmissivity values. The Hantush-Jacob method involves matching the observed time-drawdown curve to a family of theoretical curves, each with a unique deviation from the theoretical curve. Each curve has a corresponding leakage coefficient. The closest type curve to the observed curve is chosen and its corresponding leakage coefficient is obtained. The aquifer transmissivity and storativity can then be determined through a process similar to the Theis method (Freeze and Cherry 1979). The leakage coefficient can be used to obtain the vertical hydraulic conductivity of the semi-confining unit; however, its validity is questionable because the method does not use aquitard data (Neuman and Witherspoon 1972). Equations and calculations of the Hantush-Jacob method are provided in Appendix F. Storativity and transmissivity values derived using the Hantush-Jacob method are presented in Table 4-8.

Ratio Method. Neuman and Witherspoon's (1972) ratio method was used by FIT to determine aquitard diffusivity. Diffusivity is equal to the aquitard hydraulic conductivity divided by its specific storage. The ratio method provides a determination of aquitard diffusivity through an analysis of time-drawdown data from a well nest monitoring both the pumped aquifer and the semi-confining unit. The diffusivity value (D) can be used to obtain aquitard hydraulic conductivity (K) using the following formula.

$$D = \frac{K}{S_s}$$

Where: S_s = specific storage.

The specific storage of the aquitard is not determined by the ratio method, but rather by field methods (boring extensimeters) or laboratory methods (standard consolidation tests). These tests are beyond the scope of this study, and therefore, the hydraulic conductivity of the aquitard was not determined. However, the aquitard diffusivity determined using the ratio method was 51 ft.²/day at well nest GW6. Calculations used for the ratio method are provided in Appendix F.

Table 4-8

STORATIVITY AND TRANSMISSIVITY VALUES
CALCULATED USING THE HANTUSH-JACOB METHOD

Well	Storativity	Transmissivity (ft. ² /sec.)
GW1D	6.23×10^{-4}	0.175
GW2D	4.12×10^{-4}	0.221
GW6D	2.47×10^{-4}	0.325

Source: Ecology and Environment, Inc. 1989.

4.2.2.6.3 Discussion

Discussions of the FIT-conducted pre-pump test, pump test, and recovery test are presented as follow.

Pre-Pump Test. One purpose of the pre-pump test period of observation well monitoring (60 hours preceding the start of the pump test) was to identify water level fluctuation patterns in the shallow and deep wells of the three well nests: GW1, GW4, and GW6. Similar water level patterns in the deep and shallow wells of each nest would indicate possible hydraulic connection between the two aquifers. During the pre-pump test period, no well defined water level fluctuation patterns were evident. Wells GW4S and GW4D exhibited similar peaks on December 15 and 16, 1987; however, the peaks are not sufficient to conclude hydraulic connection between the upper and lower aquifers. Similar peaks were not present at the other well nests. (Figures depicting monitoring well water level fluctuations are provided in Appendix F.)

A second purpose of the pre-pump test monitoring was to identify daily water level fluctuation patterns for use in correcting the pump test data. A pattern sufficient for pump test data correction was not identified because of the strong influence of municipal well pumping on water levels in the observation wells. The irregular pumping schedule of the municipal wells (see Appendix F) is due in large part to FIT's efforts to stabilize the piezometric surface in the vicinity of municipal well 4 by shutting it off. This required municipal well 5 to pump for longer periods of time than normal. Because of the irregular pumping schedule, no consistent pattern of groundwater was able to be determined.

The pre-pump test water level data were not corrected for barometric fluctuations, although major barometric fluctuations occurred on December 14 and 15, 1987 (the pressure dropped 35 mbs) (see Appendix F). The effect of municipal well pumping is believed to be the controlling force on water level fluctuations in the monitoring wells (as was also observed during the preliminary pump test).

Pump Test. Discussions of the methods used to interpret data generated from the pump test are presented as follow.

- **Time-Drawdown Curves:** The downward deflection of the observed time-drawdown curves from the theoretical Theis curve indicates a recharge effect; water is supplied to the pumped aquifer by an outside source, slowing the rate of drawdown in the pumped aquifer. The outside source or sources may be underlying or overlying units, or a surface water (recharge) body.

- **Image Well Analysis:** The image well analysis using the method described by Walton (1962) was conducted at two different times during the pump test, neither of which indicated the presence of a boundary (no two circles intersected). (A summary of equations and calculations is provided in Appendix F.) However, the image well analysis (Moulder 1963) of the primary pump test suggests the possible presence of recharge boundaries at Silver Lake and Antioch Lake. Each circle generated using the method described by Moulder intersected a surface water body; the circle for GW10 intersected Silver Lake, and the circle for GW2D intersected Antioch Lake (a figure showing these circles has been prepared and is provided in Appendix F). The lakes, however, are shallow and may be isolated from the deep aquifer by the Wadsworth Till and the lakes' bottom sediments. Antioch Lake is not greater than 10 feet deep (Illinois Department of Conservation 1972) and Silver Lake is not deeper than 21 feet (Kuziel 1988).

- **Distance-Drawdown Analysis:** In the distance-drawdown curves prepared to illustrate aquifer boundary conditions (see Figure 4-11), the bottom curve, at $t = 50$ minutes, illustrates barrier boundary effect in the aquifer. The top curve, at $t = 1,400$ minutes, illustrates a recharge effect (possibly leakage) in the aquifer. According to Driscoll (1986), the two intermediate curves, at $t = 100$ and $t = 500$ minutes, do not show boundary effects. The barrier boundary effects on drawdown, at $t = 50$ minutes,

are possibly the result of the heterogeneity of the aquifer. Differences in hydraulic conductivity (heterogeneity) within the pumped aquifer may distort drawdown, but these effects reduce almost totally with continued pumping (Kruseman and De Ridder 1983). This phenomenon is believed to have occurred at $t = 100$ and $t = 500$ minutes, when no boundaries were evident. The recharge effect late in the test, indicated by the deflection of the curve at $t = 1,400$ minutes, is possibly attributable to leakage from confining units, recharge from surface water, or effects of nonuniform aquifer thickness. The distance-drawdown analysis alone does not establish the presence of a specific recharge boundary.

- Hantush-Jacob Method: The transmissivity and storativity values obtained using the Hantush-Jacob method (presented in Table 4-8) are relatively consistent. The values are within the range of a productive aquifer as described by Freeze and Cherry (1979) and are therefore considered accurate.
- Ratio Method: The lack of storage coefficient data regarding the till makes determining any conclusion on the hydraulic properties of the till using the ratio method difficult. The aquitard diffusivity ($51 \text{ ft.}^2/\text{day}$) was determined, but the vertical hydraulic conductivity, which indicates the aquitard leakage properties, could not be determined.

Recovery Test. The recovery test data were collected to substantiate the pump test data. However, because municipal well 5 pumped during the recovery test and no recovery test data curves were prepared, no comparison of the pump test data to the recovery test data was made.

4.2.2.6.4 Factors Affecting Drawdown Data Analysis

Many factors affect analysis of drawdown data. The following is a brief summary of factors considered in the evaluation of the pump test data.

Partial Penetration. Municipal well 4 is screened in the lower aquifer from 109 to 129 feet below ground surface. Well logs of the area of the site (see Appendix B) indicate the lower aquifer extends to approximately 230 feet below ground surface, and ranges from 40 to 148 feet thick in the immediate vicinity of the site. Municipal well 4 is partially penetrating the aquifer, and therefore, drawdown data will be distorted to resemble a recharge boundary. The effect will not affect data from wells at a distance greater than $1\frac{1}{2}$ times the aquifer thickness from the pumping well (Hantush 1961). For the primary pump test, a more conservative distance of three times the aquifer thickness was used. Wells GW3D and GW4D were not included in the data analysis because of their close proximity to the pumping well (less than 450 feet). Wells GW1D, GW2D, and GW6D were chosen as observation wells because their distances from the pumping well exceed $1\frac{1}{2}$ times the aquifer thickness.

Monitoring Well Construction. Leakage along the well pipe is a potential source of recharge to the lower aquifer, and would cause a distortion of the drawdown data. However, all FIT-installed wells were designed and constructed to insure that no leakage would occur between the clay unit and sand units (see 3.3.1 and 3.3.2).

Aquifer Heterogeneity. In a discontinuously stratified aquifer, radial flow to a well will be distorted. The drawdown curves may show a recharge effect if a zone of high hydraulic conductivity exists within the radius of influence. However, this effect and others diminish as the duration of pumping and the distance from the pumping well increases (Kruseman and De Ridder 1983).

Wells GW2D, GW6D, and GW1D were used as observation wells for the drawdown analysis. These wells are all located at distances greater than 750 feet from the pumping well, which are beyond the limit of potential drawdown distortion caused by aquifer heterogeneities

(Kruseman and De Ridder 1983), therefore, the recharge affect can be attributed to a factor other than aquifer heterogeneity.

Aquifer Thickness. The thickness of the pumped aquifer is assumed uniform for the Hantush-Jacob method. Where this is not the case, such as in a wedge-shaped aquifer, drawdown may be distorted and the drawdown curves may resemble those of a leaky aquifer (Hantush 1961). The effect of nonuniformity in aquifer thickness is dependent on the degree of non-uniformity, the radial distance of the observation well from the discharge well, and the time from the initiation of the pumping (Hantush 1962). Relatively early time-drawdown data from nearby observation wells will provide reliable results (Hantush 1962).

It is suspected that the deep aquifer is of nonuniform thickness at the site; however, sufficient data are not available to fully characterize aquifer geometry. Area well logs indicate that the aquifer thins substantially to the north and west of the site and thickens to the south of the site. According to well logs of the area of the site, the local change in aquifer thickness may be as much as 110 feet. This nonuniformity may result in distorted drawdown data, but the extent is unknown. It is suspected, however, that because of its distance from the pumping well, well GW1D may show distorted drawdown data; for example, where the recharge effect is most pronounced in the time-drawdown curve (see Appendix F).

Leakage From Below. Aquifers can receive leakage from either above or below during pumping. The effect from either situation would appear the same on the time-drawdown curves. Each would indicate semi-confined conditions. According to well logs of the area of the site, clay-rich layers within the drift directly overlie the bedrock. However, according to a well log in the area of the site, the lower sand and gravel deposit appears to be in direct contact with the bedrock. Leakage from the underlying bedrock into the lower aquifer may account for the recharge observed in the time-drawdown curves; however, leakage from above is more likely because the pumping well (municipal well 4) is screened in the upper portion of the lower aquifer and drawdown was measured in the Wadsworth Till. Also, the log of municipal well 3 (located approximately 700 feet west of municipal well 4) shows that the lower sand and gravel deposit is not in direct contact with bedrock.

Leakage From Above. The Wadsworth Till separating the upper and lower aquifers at the site is of variable thickness. It ranges from approximately 26 feet at GW6D to over 60 feet at GW1D. At GW3D, near the pumping well, it is 29 1/2 feet thick. With pumping, leakage is believed to occur from the shallow aquifer into the deep aquifer through the Wadsworth Till. No appreciable drawdown was measured in the shallow wells during the pump test; however, this may be attributed to the high horizontal hydraulic conductivity of the upper aquifer (1.02×10^{-3} ft./sec.). The high conductivity of the upper aquifer most likely caused drawdown measurements to be low. Also, intermediate-depth wells showed significant drawdown, specifically well GW3I (0.67 feet). Drawdown in the intermediate-depth wells indicates that leakage from the Wadsworth Till to the lower aquifer is occurring. It is probable that the Wadsworth Till is being recharged by the upper aquifer. Therefore, it is probable that groundwater from the upper aquifer ultimately recharges the lower aquifer.

4.2.2.6.5 Summary of Findings

The following is a summary of findings based on the primary pump test.

- The lower aquifer is semi-confined. This is evident based on observed drawdown in the intermediate wells and the shape of the time-drawdown curves.
- Recharge and discharge boundaries are not influencing groundwater flow in the vicinity of the site.
- The lower aquifer is heterogeneous.
- Pumping of village of Antioch wells has a major influence on groundwater flow in the lower aquifer.
- The lower aquifer transmissivity is approximately 0.243 ft.²/sec., and storativity is approximately 4.27×10^{-4} , based on time-drawdown analysis.

- The aquitard diffusivity is approximately 51 ft.²/day (based on the ratio method).

4.3 CHEMICAL RESULTS AND DISCUSSIONS

Chemical analysis was conducted on subsurface soil samples and groundwater samples collected from monitoring wells, residential wells, and a municipal water supply well. Summaries of the analytical results are presented and discussed in this subsection.

4.3.1 Soil Sampling

A total of 49 subsurface soil samples (S1 through S49) was collected by FIT during the drilling of seven borings for analysis for TCL compounds and TAL analytes.

Results. Table 4-9 presents a summary of the analytical results of the chemical analysis of FIT-collected subsurface soil samples and identifies the boring from which each sample was collected, the depth of each sample from within the boring, and the date on which each sample was collected and shipped to U.S. EPA CLP laboratories. (Laboratory analytical data of FIT-collected subsurface soil samples including U.S. EPA contract-required quantitation limits (CRQLs) and contract-required detection limits (CRDLs) of TCL compounds and TAL analytes analyzed for are provided in Appendix G.)

Discussion. Of the 49 soil samples collected, samples S37, S38, S39, S40, and S48 were designated as background samples. The locations from which the background samples were collected were chosen because they were less likely to be affected by landfill activities than the locations from which the other samples were collected. The samples designated as background were chosen based on their depths and their locations relative to the landfill boundaries and groundwater flow directions. Samples S37 through S40 were collected at boring GW5D. Sample S48 was collected at boring GW7S. Borings GW5D and GW7S are located north of the landfill boundary and are hydraulically upgradient of the landfill relative to the horizontal hydraulic gradients of the lower aquifer. Also, the upper aquifer present south of the landfill

Table 4-9
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED SUBSURFACE SOIL SAMPLES

Sample Collection Information and Parameters	S1	S2	S3	S4	S5	S6	Sample Number S7	S8	S9	S10	S11	S12
Date	5/26/87	5/26/87	5/26/87	5/26/87	5/26/87	5/26/87	5/26/87	5/26/87	6/3/87	6/3/87	6/3/87	6/3/87
Time	0945	1010	1030	1100	1125	1200	1240	1310	0815	0825	0840	0850
CLP Organic Traffic Report Number	EJ125	EJ126	EJ127	EJ128	EL256	EL257	EL258	EL259	EL260	EL261	EL262	EL263
CLP Inorganic Traffic Report Number	MEL574	MEL575	MEL576	MEL577	MEL578	MEM285	MEM286	MEM287	MEM288	ME3646	MEN524	MEN525
Boring Number	GW1D	GW1D	GW1D	GW1D	GW1D	GW1D	GW1D	GW1D	GW3D	GW3D	GW3D	GW3D
Sample Depth (feet)	35 to 36.5	40 to 41.5	45 to 46.5	50 to 51.5	55 to 56.5	60 to 61.5	65 to 66.5	70 to 71.5	50 to 51.5	51.5 to 53	53 to 55	55 to 57
Compound Detected (values in ug/kg)												
Volatile Organics												
chloromethane	--	--	--	--	--	--	--	--	--	--	--	--
methylene chloride	588	328	648	568	278	178	208	208	958	--	468	--
acetone	988	818	8408	3308	2208	1808	908	1908	--	--	1908	--
4-methyl-2-pentanone	--	--	--	--	--	--	--	--	--	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--	--	--	--
toluene	--	--	--	--	--	--	--	--	--	--	--	--
ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--
Semivolatile Organics												
2-methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--
diethylthalate	--	--	--	--	--	--	--	--	--	--	--	--
phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--
di-n-butylphthalate	--	1,100	350J	760J	700J	910	1,700	410J	5,500	1,800	1,000	650J
fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
pyrene	--	--	--	--	--	--	--	--	--	--	--	--
butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
benzo(a)anthracene	--	--	--	--	--	--	--	--	--	--	--	--
chrysene	--	--	--	--	--	--	--	--	--	--	--	--
bis(2-ethylhexyl)thalate	--	--	--	--	--	--	--	--	1,3008	--	--	--
di-n-octylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
benzo(b)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
benzo(k)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--	--	--	--	--	--
dibenzo(a,h)anthracene	--	--	--	--	--	--	--	--	--	--	--	--

Table 4-9 (Cont.)

Sample Collection Information and Parameters	51	52	53	54	55	56	Sample Number 57	58	59	510	511	512
Analyte Detected (values in mg/kg)												
aluminum	9,710	9,700	8,350	8,170	7,360	8,360	12,300	14,100	6,200	2,790	3,260	4,170
arsenic	12	12	13	12	10	12	15	16	9.2	20	--	6.7
barium	[47]	[47]	[40]	[44]	[39]	[39]	[57]	[66]	[37]	[21]	[22]	[27]
beryllium	--	[.82]	[.68]	[.69]	[.68]	[.68]	[1]	[1.3]	[.75]	--	--	--
calcium	76,900	72,700	84,700	90,100	91,600	100,000	86,200	80,200	83,900	123,000	102,000	103,000
chromium	18	18	17	17	15	16	24	27	13	7.3	9.4	9.6
cobalt	[9]	[9.5]	[7.7]	[8.5]	[7.7]	[6.7]	[12]	[12]	[8]	[3.2]	[4.5]	[3.8]
copper	21	21	19	21	20	20	25	27	16	[11]	[12]	[14]
iron	20,000	19,800	17,800	17,900	17,200	17,700	21,200	22,500	13,000	8,230	8,780	9,890
lead	12	9.4	10	10	11	11	11	13	7.5	6.2	4.7	5.2
magnesium	35,100	33,600	40,700	44,000	44,600	50,100	43,500	36,900	40,500	62,100	49,900	50,500
manganese	479	464	449	526	519	546	530	499	377	391	343	375
mercury	--	--	--	--	--	--	--	--	--	--	--	--
nickel	27	30	[23]	28	24	[23]	34	37	23	[14]	[16]	[18]
potassium	[2,310]	[2,330]	[2,010]	[2,080]	[1,750]	[2,240]	3,250	3,590	[1,480]	[879]	[979]	[1,090]
sodium	--	--	--	--	--	--	--	--	--	--	--	--
tin	--	--	--	--	--	--	--	--	--	--	--	--
vanadium	[20]	[21]	[19]	[20]	[17]	[19]	[25]	[27]	[15]	[10]	[11]	[13]
zinc	60	50	45	50	52	46	53	56	45	30	39	34

Table 4-9 (Cont.)

Sample Collection Information and Parameters	S13	S14	S15	S16	S17	S18	Sample Number S19	S20	S21	S22	S23	S24
Date	6/3/87	6/3/87	6/3/87	6/3/87	6/11/87	6/11/87	6/11/87	6/11/87	6/11/87	6/11/87	6/11/87	6/11/87
Time	0915	0935	1000	1025	0845	0900	0915	0930	0945	1110	1130	1150
CLP Organic Traffic Report Number	EL264	EL265	EL266	EL267	EL268	EL269	EL270	EM851	EM852	EM853	EM854	EM855
CLP Inorganic Traffic Report Number	MENS26	MENS27	MENS28	MENS29	MENS30	MENS31	MENS32	MENS33	MENS34	MENS35	MENS36	MENS37
Boring Number	GW3D	GW3D	GW3D	GW3D	GW2D	GW2D	GW2D	GW2D	GW2D	GW2D	GW2D	GW2D
Sample Depth (feet)	59 to 61	62.5 to 64	65 to 66.5	70 to 71.5	22.5 to 24	24 to 25.5	25.5 to 27	27 to 28.5	28.5 to 30	30 to 31.5	34 to 35.5	36.5 to 38
<u>Compound Detected</u> (values in µg/kg)												
<u>Volatile Organics</u>												
chloromethane	--	--	--	--	--	--	--	--	--	--	--	--
methylene chloride	17R	29R	170R	--	1,100R	730R	940R	--	56R	--	--	--
acetone	--	190R	990R	--	280	300R	170R	--	--	--	--	--
4-methyl-2-pentanone	--	--	--	--	--	--	--	--	--	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--	--	5J	--
toluene	--	--	--	--	7J	8J	6J	--	--	--	--	--
ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--
<u>Semivolatile Organics</u>												
2-methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--
diethylphthalate	--	--	--	--	--	--	--	--	--	--	50J	--
phenanthrene	--	--	--	--	--	--	--	--	--	--	56J	--
di-n-butylphthalate	2,400	1,100	470J	760J	--	--	1,000	920	840	--	700	1,100
fluoranthene	--	--	--	--	--	--	49J	--	--	--	64J	--
pyrene	--	--	--	--	--	--	52J	--	--	--	68J	--
butylbenzylphthalate	--	--	--	--	--	--	51J	--	--	--	55J	--
benzo[a]anthracene	--	--	--	--	--	--	65J	--	--	--	--	--
chrysene	--	--	--	--	--	--	--	--	--	--	--	--
bis(2-ethylhexyl)phthalate	--	--	--	--	2,400J	480J	--	--	--	--	--	--
di-n-octylphthalate	--	--	--	--	--	--	67J	--	--	--	--	--
benzo[b]fluoranthene	--	--	--	--	--	--	53J	--	--	--	57J	--
benzo[k]fluoranthene	--	--	--	--	--	--	69J	--	--	--	--	--
indeno[1,2,3-cd]pyrene	--	--	--	--	--	--	62J	--	--	--	--	--
dibenzo[a,h]anthracene	--	--	--	--	--	--	65J	--	--	--	--	--

Table 4-9 (Cont.)

Sample Collection Information and Parameters	S13	S14	S15	S16	S17	S18	Sample Number S19	S20	S21	S22	S23	S24
Analyte Detected (values in mg/kg)												
aluminum	5,710	3,440	1,390	765	3,370	2,490	6,020	6,280	6,300	6,550	6,960	5,200
arsenic	7.6	[6]	--	--	--	--	6.9	5.7	--	--	--	--
barium	[37]	[19]	[8]	[4.4]	[16]	[14]	[31]	[31]	[33]	[31]	[33]	[27]
beryllium	--	--	--	--	--	--	[.68]	[.68]	[.72]	[.82]	[.67]	[1.1]
calcium	105,000	117,000	133,000	97,100	151,000	159,000	143,000	119,000	146,000	118,000	118,000	123,000
chromium	11	7.5	[4.2]	--	7.1	[4.4]	11	10	11	11	12	10
cobalt	[7.3]	[5.3]	--	--	[3.4]	[4.8]	[7.5]	[6.2]	[7.6]	[6.3]	[5.8]	[7.4]
copper	16	[13]	[8.8]	[6.5]	17	18	21	19	22	18	19	22
iron	13,300	10,300	5,910	3,540	13,300	12,200	16,400	15,400	17,800	15,800	16,500	14,000
lead	6.4	5.5	4.6	--	8	5.9	7.6	9.3	7.9	8	7.5	8.1
magnesium	52,200	54,100	67,300	48,900	81,100	85,900	75,500	61,100	74,200	60,800	60,200	63,800
manganese	568	406	361	168	683	706	682	560	664	546	555	552
mercury	--	--	--	--	--	--	--	--	--	--	--	--
nickel	[21]	[18]	[8.4]	[5.5]	[15]	[13]	[20]	[21]	24	[20]	[21]	[18]
potassium	[1,410]	[868]	[377]	[322]	[930]	[864]	[1,660]	[1,760]	[1,520]	[1,790]	[1,900]	[1,780]
sodium	--	--	--	--	--	[601]	[539]	--	[621]	[564]	--	[932]
tin	--	--	--	--	--	--	--	--	46	--	--	--
vanadium	[15]	[11]	[6.8]	[4.9]	[12]	[11]	[16]	[15]	[16]	[16]	[17]	[16]
zinc	37	46	31	24	65	61	59	55	62	60	173	93

Table 4-9 (Cont.)

Sample Collection Information and Parameters	S25	S26	S27	S28	S29	S30	Sample Number S31	S32	S33	S34	S35	S36
Date	6/11/87	6/11/87	6/11/87	6/18/87	6/18/87	6/18/87	6/18/87	6/18/87	6/18/87	6/18/87	6/18/87	6/26/87
Time	1205	1230	1245	1405	1425	1430	1520	1540	1555	1620	1640	0815
CLP Organic Traffic Report Number	EM856	EM857	EM858	EM859	EM860	EM861	EM862	EM863	EM864	EM865	EM866	EM867
CLP Inorganic Traffic Report Number	MENS38	MENS39	MENS40	MENS41	MENS42	MENS43	MENS44	MENS45	MENS46	MENS47	MENS48	MENS49
Boring Number	GW2D	GW2D	GW2D	GW4D	GW4D	GW4D	GW4D	GW4D	GW4D	GW4D	GW4D	GW5D
Sample Depth (feet)	40 to 41.5	45 to 46.5	50 to 51.5	36 to 38	38 to 40	40 to 42	42 to 44	45 to 46.5	47.5 to 49	52.5 to 54	55 to 56.5	35 to 36.5
<u>Compound Detected</u> (values in ug/kg)												
<u>Volatile Organics</u>												
chloromethane	--	--	--	8J	--	--	--	--	--	--	--	--
methylene chloride	300B	350B	300B	28B	92B	21B	30B	31B	41B	26B	211B	226B
acetone	--	200B	180B	39B	54B	16B	49B	44B	84B	86B	69B	34B
4-methyl-2-pentanone	--	--	--	--	18J	--	--	--	--	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--	--	--	--
toluene	--	2J	2J	--	28J	--	1J	--	--	--	18J	2J
ethylbenzene	--	--	--	--	--	--	--	--	--	18J	--	--
<u>Semivolatile Organics</u>												
2-methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--
diethylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
phenanthrene	--	--	--	--	--	--	58J	52J	66J	--	--	--
di-n-butylphthalate	1,600	2,300	1,000	420B	1,400B	200B	150B	160B	120B	260B	340B	830
fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
pyrene	--	--	--	--	--	--	--	--	--	--	--	--
butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
benzo[a]anthracene	--	--	--	--	--	--	--	--	--	--	--	--
chrysene	--	--	--	--	--	--	--	--	--	--	--	--
bis(2-ethylhexyl)phthalate	--	--	--	710B	450B	390B	480B	660B	220B	420B	190B	170B
di-n-octylphthalate	--	--	--	58J	--	--	--	82J	--	83J	--	--
benzo[b]fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
benzo[k]fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
indeno[1,2,3-cd]pyrene	--	--	--	--	--	--	--	--	--	--	--	--
dibenzo[a,h]anthracene	--	--	--	--	--	--	--	--	--	--	--	--

Table 4-9 (Cont.)

Sample Collection Information and Parameters	S25	S26	S27	S28	S29	S30	Sample Number S31	S32	S33	S34	S35	S36
<u>Analyte Detected</u> (values in mg/kg)												
aluminum	5,710	5,640	8,670	5,130	4,900	7,640	7,790	8,350	10,800	8,120	1,520	6,710
arsenic	--	--	--	7.4	7.8	10	13	12*	12	10	7.6	--
barium	[28]	[28]	[40]	[35]	[31]	[47]	[43]	[46]	[61]	[50]	[11]	[35]
beryllium	[.81]	--	[.83]	[.7]	[.87]	[.85]	[.88]	[.88]	[1.2]	[1.1]	--	[.81]
calcium	137,000	134,000	102,000	104,000	116,000	135,000	77,800	126,000	64,800	81,800	15,600	92,700
chromium	10	9.8	14	9.9	10	15	15	17	19	18	[3.8]	10
cobalt	[6.1]	[6]	[9.1]	[7.9]	[6.9]	[10]	[10]	[13]	[13]	[10]	--	[7.7]
copper	19	21	20	22	22	29	31	29	26	23	[7.3]	16
iron	15,600	15,200	18,000	14,000	14,600	20,200	17,800	22,000	20,300	16,600	3,090	15,900A]
lead	8.5	8.6	9.9	10J	9.4J	13J	16J	16J	16J	13J	8.9J	12B]
magnesium	71,300	70,200	50,900	50,000	58,900	66,500	38,200	66,800	32,300	39,000	7,340	47,300
manganese	642J	658J	508J	475	552	631	461	713	434	438	84	467
mercury	--	--	--	--	--	--	--	--	--	--	--	--
nickel	[21]	[18]	25	[20]	[19]	34	31	34	40	34	[8.7]	[18]
potassium	[1,510]	[1,590]	[2,240]	[1,170]	[1,140]	[1,620]	[1,750]	[1,790]	[2,290]	[1,750]	[451]	[1,590]
sodium	[615]	[610]	[678]	[518]	[778]	--	[1,130]	[808]	--	[976]	[1,230]	[893]
tin	--	--	--	--	--	--	--	--	--	--	--	--
vanadium	[15]	[15]	[18]	[14]	[15]	[19]	[19]	[21]	[24]	[20]	[4.9]	[15]
zinc	52	56	50	47	58	65	62	60	63	56	14	46

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number											
	S37	S38	S39	S40	S41	S42	S43	S44	S45	S46	S47	S48
Date	6/26/87	6/26/87	6/26/87	6/26/87	7/6/87	7/6/87	7/6/87	7/6/87	7/6/87	7/16/87	7/16/87	7/16/87
Time	0835	0930	1005	1130	0910	0925	0935	1055	1015	0805	1100	1120
CLP Organic Traffic Report Number	EMB68	EMB69	EMB70	EMB71	EMB72	EMB73	EMB74	EMB75	EMB76	EMB77	EMB78	EMB79
CLP Inorganic Traffic Report Number	MEN550	MEN551	MEN552	MEN553	MEN554	MEN555	MEN556	MEN557	MEN558	MEN559	MEN560	MEN561
Boring Number	GW5D	GW5D	GW5D	GW5D	GW6D	GW6D	GW6D	GW6D	GW6D	GW7S	GW7S	GW7S
Sample Depth (feet)	37.5 to 39	42.5 to 44	50 to 51.5	65 to 66.5	59 to 61	61 to 63	63 to 65	65 to 67	69.5 to 71	24 to 25.5	34.5 to 36	37 to 38.5
Compound Detected (values in µg/kg)												
<u>Volatile Organics</u>												
chloromethane	--	--	--	--	--	--	--	--	--	--	--	--
methylene chloride	61B	41B	29B	49B	--	--	--	--	--	--	--	--
acetone	50B	31B	26B	64B	--	--	--	--	--	36	--	38
4-methyl-2-pentanone	--	--	--	--	--	--	--	--	--	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--	--	--	--
toluene	1J	1J	1J	2J	--	--	--	--	--	--	--	--
ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--
<u>Semivolatile Organics</u>												
2-methylnaphthalene	--	--	--	--	--	--	--	--	51J	--	--	--
diethylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
phenanthrene	--	--	--	--	--	--	--	--	83J	--	--	--
di-n-butylphthalate	1,100	820	810	820	--	--	--	--	--	330J	240J	450J
fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
pyrene	--	--	--	--	--	--	--	--	--	--	--	--
butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
benzo(a)anthracene	--	--	--	--	--	--	--	--	--	--	--	--
chrysene	--	--	--	--	--	--	--	--	51J	--	--	--
bis(2-ethylhexyl)phthalate	1808J	3108J	7308	2808J	--	--	--	--	--	--	--	--
di-n-octylphthalate	--	--	--	--	--	--	--	--	--	--	--	--
benzo(b)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
benzo(k)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--
indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--	--	--	--	--	--
dibenzo(a,h)anthracene	--	--	--	--	--	--	--	--	--	--	--	--

Table 4-9 (Cont.)

Sample Collection Information and Parameters	S37	S38	S39	S40	S41	S42	Sample Number S43	S44	S45	S46	S47	S48
Analyte Detected (values in mg/kg)												
aluminum	6,400	6,110	5,520	12,300	7,780	2,000	3,820	4,520	8,130	8,270	8,010	8,170
arsenic	--	--	--	--	8.2J	--	--	--	--	16	8.3	15
barium	[34]	[33]	[31]	[67]	[54]	[16]	[27]	[31]	[57]	[50]	[47]	[43]
beryllium	[.67]	--	[.82]	[.89]	[.86]	--	--	--	[.94]	--	--	[.66]
calcium	97,600	96,200	103,000	55,700	75,500	110,000	109,000	90,300	71,600	90,000	93,100	95,400
chromium	11	9	9.3	20	14	6.4	8.5	9.8	16	17	15	15
cobalt	[8]	[6.2]	[5.4]	[12]	[11]	[4.3]	[5.4]	[7.3]	[12]	[12]	[8.2]	[9.8]
copper	17	16	17	20	25	[14]	[15]	14	25	27	24	28
iron	15,700AJ	15,500AJ	14,600AJ	21,200AJ	16,700	8,900	9,360	10,500	15,700	19,100	17,700	18,800
lead	8.7RJ	10RJ	9.4RJ	12RJ	11	5.7	6.7	7.4	12	10	11	12
magnesium	50,300	49,400	53,400	30,000	35,000	53,100	53,000	43,700	32,300	45,800	46,500	47,200
manganese	482	497	505	396	427	326	375	356	377	537	513	530
mercury	--	--	--	--	--	--	--	--	--	--	--	.29
nickel	24	19	[18]	36	29	[12]	[11]	[17]	30	33	26	25
potassium	[1,540]	[1,470]	[1,330]	[2,740]	[1,820]	[548]	[932]	[1,110]	[1,940]	[2,310]	[2,310]	[2,370]
sodium	[575]	[548]	[931]	[661]	--	--	--	[783]	[808]	--	--	--
tin	--	--	--	--	[14]	[14]	[11]	--	--	--	--	--
vanadium	[15]	[14]	[13]	[22]	[17]	[7.6]	[11]	[12]	[19]	[21]	[18]	[18]
zinc	47	49	46	57	48	31	32	35	48	59	84	80

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number 549
Date	7/16/87
Time	1130
CLP Organic Traffic Report Number	EN880
CLP Inorganic Traffic Report Number	MEN562
Boring Number	GW7S
Sample Depth (feet)	39.5 to 41
Compound Detected (values in ug/kg)	
Volatile Organics	
chloromethane	--
methylene chloride	--
acetone	--
4-methyl-2-pentanone	--
2-hexanone	--
toluene	--
ethylbenzene	--
Semivolatile Organics	
2-methylnaphthalene	--
diethylphthalate	--
phenanthrene	--
di-n-butylphthalate	2901
fluoranthene	--
pyrene	--
butylbenzylphthalate	--
benzo[a]anthracene	--
chrysene	--
bis(2-ethylhexyl)phthalate	--
di-n-octylphthalate	--
benzo[b]fluoranthene	--
benzo[k]fluoranthene	--
indeno[1,2,3-cd]pyrene	--
dibenzo[a,h]anthracene	--

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number 549
<u>Analyte Detected</u>	
(values in $\mu\text{g/kg}$)	
aluminum	7,590
arsenic	8.3
barium	[42]
beryllium	[.66]
calcium	91,200
chromium	14
cobalt	[9.2]
copper	25
iron	17,700
lead	12
magnesium	46,400
manganese	501
mercury	--
nickel	26
potassium	(2,070)
sodium	[748]
tin	--
vanadium	[18]
zinc	80

-- Not detected.

Table 4-9 (Cont.)

COMPOUND QUALIFIERS

J
B

DEFINITION

Indicates an estimated value.
This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.

INTERPRETATION

Compound value may be semiquantitative.
Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS

R
A
+
[]
J

DEFINITION

Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.
Duplicate value outside QC protocols which indicates a possible matrix problem.
Correlation coefficient for standard additions is less than 0.995. See review and laboratory narrative.
Value is real, but is above instrument DL and below CRDL.
Value is above CRDL and is an estimated value because of a QC protocol.

INTERPRETATION

Value may be quantitative or semi-quantitative.
Value may be quantitative or semiquantitative.
Data value may be biased.
Value may be quantitative or semi-quantitative.
Value may be semiquantitative.

Source: Ecology and Environment, Inc. 1989.

does not exist at borings GW5D and GW7S. It was not the intent of this study to determine the distribution of naturally occurring soil constituents in the area of the site. Rather, the analytical results of the background samples were used to assess, in general, the concentrations of soil constituents from borings in the vicinity of the site least likely to be affected by the landfill.

Organic compound analysis of subsurface soil samples revealed the presence of VOCs and semivolatile organic compounds. No PCBs or pesticides were detected in any of the soil samples.

All VOCs detected in the FIT-collected samples are considered common laboratory or field artifacts at the concentrations detected.

All semivolatile organic compounds detected were either phthalates or polyaromatic hydrocarbons (PAHs). The phthalates (at the concentrations detected) are considered field or laboratory artifacts.

PAH compounds were detected in only six of the soil samples. No PAH compounds were detected in the background soil samples. Analysis of samples S31, S32, and S33 revealed the presence of phenanthrene. The concentrations of phenanthrene detected were estimated and were below the CRQL. Analysis of sample S45 revealed the presence of three PAH compounds: 2-methylnaphthalene, phenanthrene, and chrysene; all detected at estimated concentrations below the CRQLs. Sample S23 contained phenanthrene, fluoranthene, pyrene, and benzo[b]fluoranthene at estimated values below the CRQLs. Sample S19 contained the following PAH compounds, each detected at estimated concentrations below the CRQLs: fluoranthene, pyrene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, and dibenzo[a,h]anthracene. Samples S19 and S23 were collected from off-site boring GW2D. Boring GW2D is located at a parking lot and tractor-trailer staging area of an industrial property located adjacent to, and southwest of, the site. Contaminants detected in samples collected from this area do not appear to be attributable to H.O.D. Landfill.

Inorganic analytical data of subsurface soil samples were compared to analytical data of the background samples. None of the TAL analytes in the nonbackground samples were detected at concentrations greater than one order of magnitude above the highest detected TAL concentrations of the background samples.

The distribution of concentrations of TCL compounds and TAL analytes detected in FIT-collected subsurface soil samples does not demonstrate a pattern that can be used to attribute detected compounds or analytes to the site.

4.3.2 Groundwater Sampling

Three rounds of groundwater sampling were conducted by FIT on-site and in the vicinity of the site. Wells sampled included FIT-installed monitoring wells, WMII monitoring wells, local residential wells, and village of Antioch municipal well 4. Specific wells sampled, parameters sampled for, and quantitation/detection limits varied between sampling rounds. The variations are described in the following discussions of each round of sampling.

4.3.2.1 Round 1 Sampling

Round 1 sampling was the most comprehensive of the three rounds of sampling. Groundwater samples were collected from FIT-installed and WMII monitoring wells, residential wells, and village of Antioch municipal well 4 (see Figure 3-6 for sampling locations).

4.3.2.1.1 Monitoring Well Samples

Results. A summary of the analytical results and field measurements of the monitoring well samples is presented in Table 4-10. (Laboratory analytical data, including CRQLs and CRDLs of TAL analytes and TCL compounds analyzed for, are provided in Appendix H.) Nine monitoring well samples were reanalyzed for semivolatile compounds because the original surrogates were out of quality control limits. The values in Table 4-10 reflect the results of the reanalyzed samples.

Discussion. Organic analysis of round 1 monitoring well samples revealed the presence of nine organic compounds. Four of the compounds detected (methylene chloride, acetone, butylbenzylphthalate, and bis[2-ethylhexyl]phthalate) are considered common laboratory or field artifacts. The other compounds detected are not common laboratory or field artifacts and are considered representative of the sample. Phenol, detected in a field blank sample, and n-nitrosodiphenylamine

Table 4-10
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED GROUNDWATER SAMPLES -- ROUND 1

Sample Collection Information and Parameters	Sample Number									
	1S	1D	3S	4S	4D	5D	6S	6I	6D	7S
Sampling Location	GW1S	GW1D	GW3S	GW4S	GW4D	GW5D	GW6S	GW6I	GW6D	GW7S
Date	8/11/87	8/11/87	8/11/87	8/10/87	8/10/87	8/11/87	8/11/87	8/12/87	8/11/87	8/11/87
Time	1830	1958	1525	1609	1652	1640	1215	1030	1158	1330
CLP Organic Traffic Report Number	ET982	ET983	ET984	ET985	ET986	ET987	ET988	ET989	ET990	ET991
CLP Inorganic Traffic Report Number	MEU982	MEU983	MEU984	MEU985	MEU986	MEU987	MEU988	MEU989	MEU990	MEU991
Temperature (°F)	64.5	59	69.2	41.5	43	64	68.2	61.8	68.4	66.3
Specific Conductivity (µmhos/cm)	540	590	250	200	430	235	800	485	360	250
pH	7.45	7.54	7.45	7.19	7.84	8.28	7.24	7.87	7.73	7.45
<u>Compound Detected</u> (values in µg/L)										
<u>Volatile Organics</u>										
methylene chloride	--	--	--	--	3J	--	--	--	--	--
acetone	6J	7J	--	--	--	9J	7J	--	7	5J
trans-1,2-dichloroethene	--	--	--	7I	--	--	--	--	--	--
trichloroethene	--	--	--	--	--	--	--	7	--	--
benzene	--	--	--	--	--	--	--	--	--	8
<u>Semivolatile Organics</u>										
phenol	--	--	--	--	--	--	--	--	--	--
n-nitrosodiphenylamine	--	2J	--	--	--	--	--	--	--	--
butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--
bis(2-ethylhexyl)phthalate	--	--	--	37B	4J	2J	--	--	4J	13
<u>Analyte Detected</u> (values in µg/L)										
aluminum	--	--	--	--	[189]	--	--	--	--	--
barium	[38]	[91]	[50]	[88]	[70]	--	[72]	[32]	[56]	[53]
calcium	74,100	61,700	89,100	113,000	45,000	20,300	118,000	51,200	47,000	99,200
iron	270	270	1,090	1,240	110	--	1,080	--	--	--
magnesium	36,500EJ	38,300EJ	38,000EJ	52,000EJ	36,500EJ	18,300EJ	53,100EJ	40,600EJ	28,400EJ	87,500EJ
manganese	226	55	84	--	25	11	113	42	31	208
potassium	[630]	[2,230]	[2,020]	[1,320]	[1,710]	[1,300]	[1,290]	[1,700]	[1,740]	[4,300]
silver	--	--	--	--	--	--	--	--	--	--
sodium	14,400	37,500	79,200	52,700	29,200	54,900	21,800	30,100	42,800	81,500
zinc	42EJ	31EJ	38EJ	--	55EJ	24EJ	61EJ	28EJ	28EJ	41EJ

Table 4-10 (Cont.)

Sample Collection Information and Parameters	B1	DP	B2	MW10	Sample Number MW2	MW3	MW45	MW48	B3
Sampling Location	Blank	GW6S	Blank	6110	6102	6103	614S	614D	Blank
Date	8/10/87	8/11/87	8/11/87	8/12/87	8/12/87	8/12/87	8/12/87	8/12/87	8/12/87
Time	1736	1225	1729	1335	1500	1317	1551	1610	1140
CLP Organic Traffic Report Number	ET992	ET993	EN44S	ET995	ET996	ET997	ET998	ET999	ET1000
CLP Inorganic Traffic Report Number	MEU992	MEU993	MEM081	MEU995	MEU996	MEU997	MEU998	MEU999	MEU1000
Temperature (°F)	†	68.2	†	69.5	64.6	65.1	73.2	62.5	81.8
Specific Conductivity (µmhos/cm)	†	800	†	450	450	1400	705	640	0
pH	†	7.24	†	7.61	7.22	6.95	7.45	7.33	5.72
<u>Compound Detected</u> (values in µg/L)									
<u>Volatile Organics</u>									
methylene chloride	5J	--	--	--	--	--	--	--	--
acetone	--	5J	6J	--	--	--	--	--	--
trans-1,2-dichloroethene	--	--	--	--	--	--	--	--	--
trichloroethene	--	--	--	--	--	--	--	--	--
benzene	--	--	--	--	--	--	--	--	--
<u>Semivolatile Organics</u>									
phenol	2J	--	--	††	--	--	--	--	--
n-nitrosodiphenylamine	--	--	--	††	--	--	--	--	--
butylbenzylphthalate	--	--	--	††	--	--	--	--	11
bis(2-ethylhexyl)phthalate	8J	10	3J	††	6J	9J	31	4,100	26
<u>Analyte Detected</u> (values in µg/L)									
aluminum	--	--	--	--	--	--	--	--	--
barium	--	[63]	--	[167]	[114]	[38]	[38]	[143]	--
calcium	--	110,000	--	105,000	126,000	349,000	107,000	76,800	--
iron	--	190	--	6,890	3,010	8,920	1504	1,760	--
magnesium	--	52,200EJ	--	96,300EJ	51,900EJ	146,000EJ	43,800EJ	52,900EJ	--
manganese	--	101	--	51	71	193	108	30	--
potassium	--	[1,110]	--	[1,850]	[1,940]	[2,140]	--	[1,600]	--
silver	--	--	--	--	--	[9]	--	--	--
sodium	--	20,700	--	19,900	57,400	28,000	[3,610]	24,500	--
zinc	[103EJ]	40EJ	[93EJ]	3,110EJ	78EJ	52EJ	3,340EJ	359EJ	--

† These measurements were not taken by FIIT.

†† These compounds were not analyzed for.

-- Not detected.

Table 4-10 (Cont.)

COMPOUND QUALIFIERS

DEFINITION

INTERPRETATION

J
B

Indicates an estimated value.
This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.

Compound value may be semiquantitative.
Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS

DEFINITION

INTERPRETATION

E

Estimated or not reported due to interference. See laboratory narrative.

Analyte or element was not detected, or value may be semiquantitative.

[]

Value is real, but is above instrument DL and below CRDL.

Value may be quantitative or semiquantitative.

J

Value is above CRDL and is an estimated value because of a QC protocol.

Value may be semiquantitative.

A

QC-required duplicate precision not met.

Value may be semiquantitative.

Source: Ecology and Environment, Inc. 1989.

were detected at estimated concentrations below the CRQLs. Trichloroethene (TCE), benzene, and trans-1,2-dichloroethene were also detected. Benzene and trichloroethene were detected at concentrations slightly above the CRQLs. Trans-1,2-dichloroethene was detected in the sample collected from well GW4S at a concentration of 71 µg/L, greater than 14 times the CRQL.

Inorganic analysis of round 1 monitoring well samples revealed the presence of 10 analytes, all of which are considered common groundwater constituents. Aluminum was detected at 189 µg/L (in well GW4D). Silver was detected at 9 µg/L (in well G14S), below the maximum contaminant level (MCL)(50 µg/L) of the federal drinking water standards established for silver (U.S. EPA 1975).

The concentrations of barium detected in the monitoring well samples were similar for each sample and were all below the federal drinking water standard MCL established for barium (1,000 µg/L). Magnesium, potassium, and sodium are all major groundwater constituents and are generally expected to be detected at high concentrations. Calcium, also a major groundwater constituent, was detected at concentrations that correlated to the aquifer in which the respective wells were screened. Samples collected from monitoring wells screened in the lower sand and gravel aquifer revealed lower calcium concentrations than those samples collected from wells screened in the upper aquifer. The differences in concentrations of calcium detected between the two aquifers is possibly the result of the different geologic units in which each aquifer is situated. Additionally, the concentrations of manganese detected in monitoring well samples correlated to the aquifer in which the respective wells were screened. Concentrations of manganese detected in the groundwater samples of the lower aquifer were lower than those detected in the upper aquifer, possibly the result of the different geologic units in which each aquifer is situated.

Iron concentrations detected in samples collected from monitoring wells screened in the lower aquifer were significantly lower than the iron concentrations detected in samples collected from the wells screened in the upper geologic units. Additionally, of the wells screened in the upper geologic units, the iron concentrations detected in samples collected from WMII monitoring wells were significantly

higher than those of samples collected from FIT-installed monitoring wells. The difference of iron concentrations detected between the samples may have been caused by the differing geologic materials in which the wells are screened. The difference of iron concentrations detected between WMII monitoring wells and FIT-installed monitoring wells may also be the result of different well purging and sample collection procedures and different well construction design and materials of the FIT-installed wells as compared to the WMII-installed wells. The distribution of zinc concentrations detected in the FIT-installed monitoring wells was relatively uniform. The distribution of zinc concentrations detected in WMII monitoring wells varied greatly. Of the five WMII wells sampled, two contained zinc concentrations similar to concentrations detected in the FIT-installed monitoring wells. The remaining WMII wells contained zinc concentrations up to 83 times the average of the zinc concentrations detected in samples collected from all other monitoring wells. The correlation of high zinc concentrations to WMII monitoring wells possibly supports WMII's claim that the source of zinc contamination during previous sampling may have been from deteriorating galvanized steel monitoring well protector pipes. However, this claim cannot be justified solely using the sample results of this inspection because records indicate that waste containing zinc was disposed of at the landfill.

4.3.2.1.2 Drinking Water Samples

Results. A summary of the analytical results and field measurements of FIT-collected drinking water samples collected from residential wells and village of Antioch municipal well 4 are presented in Table 4-11 (Laboratory analytical data, including CRQLs and CRDLs of TAL analytes and TCL compounds analyzed for, are provided in Appendix H.)

Discussion. Only four organic compounds were detected in the FIT-collected drinking water samples. Each of the compounds (acetone, toluene, diethylphthalate, and di-n-butylphthalate) is considered a common laboratory artifact at the concentrations detected.

Inorganic analysis of the drinking water samples revealed the presence of 13 inorganic analytes, all of which are naturally occurring. The concentrations of detected analytes were compared to either the

Table 4-11
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED DRINKING WATER SAMPLES--ROUND 1

Sample Collection Information and Parameters	RW1	RW2	RW3	RW4	Sample Number		RW7	RW8	RW9	RW10
					RW5	RW6				
Date	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87	8/13/87
Time	0900	0920	0925	0935	0945	1025	1055	1110	1100	1115
CLP Organic Traffic Report Number	ET330	ET331	ET332	ET333	ET334	ET335	EK741	EK742	EK743	EK744
CLP Inorganic Traffic Report Number	MEU330	MEU331	MEU332	MEU333	MEU334	MEU335	MEU336	MEU337	MEU338	MEU339
Temperature (°F)	65.8	61.5	68.4	63.5	66.8	63.1	65.8	60.3	†	60.3
Specific Conductivity (µmhos/cm)	300	350	390	370	400	340	560	390	†	390
pH	7.64	7.80	7.54	7.98	8.23	8.25	7.65	7.85	†	7.85
<u>Compound Detected</u> (values in µg/L)										
<u>Volatile Organics</u>										
acetone	2JB	--	--	--	7JB	--	--	--	3JB	--
toluene	--	--	--	--	--	1	--	--	--	--
<u>Semivolatile Organics</u>										
diethylphthalate	--	--	--	--	3	--	--	--	--	--
di-n-butylphthalate	--	--	--	--	--	3	--	--	--	--
<u>Analyte Detected</u> (values in µg/L)										
arsenic	--	--	2Js	--	--	--	--	--	--	--
barium	238	112	129	--	53	--	[47.6]	57.1	--	53
calcium	73,600	33,400	32,400	26,200	25,800	22,300	65,600	35,100	--	35,300
chromium	--	11.6	--	--	--	[9.4]	--	--	--	--
copper	--	10.7J	--	--	--	17.6J	19.4J	[9.4J]	--	--
iron	2,540	552	539	175	175	198	370	564	--	564
lead	--	--	2.45s	--	--	--	--	--	--	--
magnesium	46,200	14,200	14,800	16,300	16,400	18,100	42,100	24,600	--	24,800
manganese	18.2	[7.5]	--	--	--	--	24.8	[8.6]	--	[8.6]
potassium	[1.120]	[817]	[885]	--	--	[599]	[575]	[614]	--	[512]
sodium	53,000	49,000	49,400	57,300	58,900	56,600	25,000	44,600	--	45,100
thallium	4.87sAJ	4.25sAJ	3.91sAJ	5.3sAJ	5.76sAJ	4sAJ	--	8.91sAJ	4.85sAJ	3.5sAJ
zinc	206	[17.6]	1,090	41.6	34.6	26.6	503	[7.9]	--	--

† These measurements were not taken by FIT.
-- Not detected.

Table 4-11 (Cont.)

COMPOUND QUALIFIERS

J
B

DEFINITION

Indicates an estimated value.
This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.

INTERPRETATION

Compound value may be semiquantitative.
Compound value may be semiquantitative if it is $\leq 5\times$ the blank concentration ($<10\times$ the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS

S

A

[]

J

DEFINITION

Analysis by Method of Standard Additions.
Duplicate value outside QC protocols which indicates a possible matrix problem.
Value is real, but is above instrument DL and below CRDL.
Value is above CRDL and is an estimated value because of a QC protocol.

INTERPRETATION

Value is quantitative.
Value may be quantitative or semiquantitative.
Value may be quantitative or semi-quantitative.
Value may be semiquantitative.

Source: Ecology and Environment, Inc. 1989.

national primary or secondary drinking water regulation MCLs established by the U.S. EPA under the Safe Drinking Water Act. The primary MCLs are set according to health criteria. Contaminants covered by the secondary MCLs may adversely affect the aesthetic quality of drinking water. The secondary MCLs are only recommended target levels. However, at concentrations considerably higher than the secondary levels, these contaminants may also be associated with adverse health effects (Driscoll 1986).

Of the analytes detected, primary MCLs exist only for arsenic, barium, chromium, and lead. The concentrations of each of these analytes detected in the drinking water samples are below the MCLs and are not considered to pose a health threat. Secondary MCLs exist for copper, iron, manganese, and zinc. Of these contaminants, only iron was detected at concentrations above the secondary MCL. Concentrations of iron exceeded the MCL of 300 µg/L in five of the eight drinking water wells sampled. Although the MCLs were exceeded, the iron concentrations detected are common in groundwater. The recommended MCL of iron is established, in part, because iron contamination of water may cause staining of plumbing fixtures and laundry and may cause encrustation of well screens and water pipes (Driscoll 1986).

The remaining analytes detected in the drinking water samples do not have established MCLs. Calcium, magnesium, and sodium are all major constituents of groundwater and are generally detected at high concentrations. Potassium is a minor constituent of groundwater and is common at concentrations between 10 and 10,000 µg/L. The highest potassium concentration detected of the drinking water samples was 1,120 µg/L. Thallium, a trace groundwater constituent, is commonly detected at concentrations below 100 µg/L (Davis and De Wiest 1966). Thallium was detected in the drinking water samples at concentrations below 10 µg/L.

Upon completion of round 1 groundwater sampling, U.S. EPA provided WMII with analytical results of all groundwater samples collected. WMII subsequently submitted comments to U.S. EPA regarding the analytical results. The WMII comments focused on the detection of trans-1,2-dichloroethene in the sample collected from well GW4S. It was the opinion of WMII that the detection of trans-1,2-dichloroethene was not indicative of a release from the landfill. WMII stated that it was

suspicious that the trans-1,2-dichloroethene had been introduced either during the well installation or the sampling event (WMII 1987a). It was also the opinion of WMII that the water quality data obtained from well GW4S was biased because of the presence of landfill gas within the headspace of the well and that the presence of gas within a well headspace could contaminate groundwater samples obtained from a well (WMII 1987). WMII did not state whether the sample contamination had occurred as a result of the static groundwater within the well being in contact with the headspace gas or whether the contamination had occurred as each bailer (filled with sample water) was passed through the headspace gas.

Based on its suspicion that the sample collected from well GW4S was not representative of the groundwater, WMII felt that confirmation of the initial results was necessary to provide accurate information on which to base subsequent decisions regarding the landfill status. WMII suggested that additional water samples be collected from well GW4S. WMII recommended that a groundwater sample be collected after the purging of one static well volume of water. Upon completion of the sample collection, WMII suggested that purging should continue, with separate groundwater samples obtained after the purging of 3, 6, and 10 static well volumes of water, and each respective sample should be analyzed for VOCs. According to WMII, analyzing these additional groundwater samples would serve two functions: 1) provide a check on the original sampling procedures, and 2) provide information regarding the presence of trans-1,2 dichloroethene at successive distances away from well GW4S (WMII 1987).

In response to WMII comments, U.S. EPA tasked FIT to collect additional groundwater samples from FIT-installed monitoring wells (including GW4S) and WMII well G102. Round 2 sampling was subsequently designed to address WMII's comments.

4.3.2.2 Round 2 Sampling

Round 2 sampling consisted of the resampling of FIT-installed monitoring wells and WMII well G102, and the collection of a duplicate sample and distilled water field blank samples (see Figure 3-6 for sampling locations). All samples were analyzed for VOCs only. During round 2 groundwater sampling, FIT-installed monitoring well samples were

collected using a submersible pump. The WMII well sample was collected using the dedicated pump system used during round 1 sampling. Detailed sample collection procedures are discussed in 3.4.2.2.

The original U.S. EPA CLP Statement of Work (SOW) for organic analysis required the CLP laboratories used by FIT to analyze for trans-1,2-dichloroethene. Round 1 samples were analyzed under the original SOW. The original SOW was subsequently revised by U.S. EPA and required CLP laboratories to analyze for total-1,2-dichloroethene. Total-1,2-dichloroethene analysis includes analysis for both trans-1,2-dichloroethene and cis-1,2-dichloroethene and is reported as a single concentration value. Samples collected during round 2 and round 3 were analyzed under the revised SOW.

An electric submersible pump was used during round 2 sampling to purge and collect water from FIT-installed wells to evaluate WMII's opinion that contamination of the sample from well GW4S was a result of passing the sample through well headspace gas during round 1 sampling. By using a submersible pump to remove water from FIT-installed monitoring wells, the following conditions were controlled:

- Purge water and sample water were not exposed to the well headspace gas (sample water within the submersible pump and discharge tubing contacted only Teflon and stainless steel); and
- The maximum drawdown of water within the well was controlled to not drop below the top of the well screen.

Results. A summary of the analytical results and field measurements of FIT-collected groundwater samples collected during round 2 sampling is presented in Table 4-12. (Laboratory analytical data, including CROs of VOCs analyzed for, are provided in Appendix I.)

Discussion. Analysis of round 2 samples revealed the presence of six VOCs. Four of the compounds detected (methylene chloride, acetone, 2-butanone [MEK], and toluene) are all common field or laboratory artifacts at the concentrations detected. The other VOCs detected, trichloroethene and total-1,2 dichloroethene, are not common field or

Table 4-12
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED GROUNDWATER SAMPLES--ROUND 2

Sample Collection Information and Parameters	Sample Number							
	1S	1D	3S	4SA	4SB	4SC	4SD	4D
Sampling Location	GW1S	GW1D	GW3S	GW4S	GW4S	GW4S	GW4S	GW4D
Date	4/19/88	4/19/88	4/19/88	4/18/88	4/18/88	4/18/88	4/18/88	4/18/88
Time	1240	1217	1037	1205	1210	1220	1230	1420
CLP Organic Traffic Report Number	EW401	EW402	EW403	EW404	EW405	EW406	EW407	EW408
Temperature (°C)	6	10	11	†	†	11	9	11
Specific Conductivity (µmhos/cm)	600	690	1,100	†	†	1,000	700	350
pH	7.13	7.45	7.17	†	†	7.08	7.13	7.83
<u>Compound Detected</u> (values in µg/L)								
<u>Volatile Organics</u>								
methylene chloride	1BJ	.98J	2BJ	2BJ	3BJ	2BJ	4BJ	5BJ
acetone	1BJ	2BJ	3BJ	3BJ	5BJ	3BJ	2BJ	5BJ
1,2-dichloroethene (total)††	--	--	--	69	79	96	100	--
2-butanone (MEK)	--	--	--	--	--	--	--	--
trichloroethene	--	--	--	--	--	--	--	--
toluene	--	--	--	--	--	--	1J	--

Table 4-12 (Cont.)

Sample Collection Information and Parameters	Sample Number							
	6S	6I	6D	7S	6I02	Duplicate	Blank	Blank
Sampling Location	GW6S	GW6I	GW6D	GW7S	6I02	GW6I	Blank	Blank
Date	4/18/88	4/18/88	4/19/88	4/18/88	4/18/88	4/18/88	4/18/88	4/19/88
Time	1650	1817	0938	1555	1410	1817	1150	0841
CLP Organic Traffic Report Number	EW410	EW411	EW412	EW413	EW414	EW415	EW416	EW417
Temperature (°C)	9	8	10	9.5	10	8	†	6.0
Specific Conductivity (µmhos/cm)	1,300	1,200	320	1,400	800	1,200	†	0
pH	7.14	8.4	7.51	7.10	7.38	8.4	†	6.0
<u>Compound Detected</u> (values in µg/L)								
<u>Volatile Organics</u>								
methylene chloride	3BJ	2BJ	2BJ	2BJ	2BJ	2BJ	1BJ	2BJ
acetone	5BJ	5BJ	4BJ	4BJ	5BJ	4BJ	5BJ	7BJ
1,2-dichloroethene (total) ††	--	--	--	--	--	--	--	--
2-butanone (MEK)	--	--	--	--	2BJ	--	3BJ	--
trichloroethene	--	5	--	--	--	5	--	--
toluene	--	2J	--	--	2J	--	1J	3J

† These measurements were not taken by FII.

†† Groundwater samples collected during round 2 were analyzed for 1,2-dichloroethene (total), as opposed to a distinct analysis for trans-1,2-dichloroethene, which was conducted for groundwater samples collected during round 1.

-- Not detected.

Table 4-12 (Cont.)

COMPOUND QUALIFIERS

DEFINITION

INTERPRETATION

J

8

Indicates an estimated value.

This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.

Compound value may be semiquantitative.

Compound value may be semiquantitative if it is $\leq 5\times$ the blank concentration ($\leq 10\times$ the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

Source: Ecology and Environment, Inc. 1989.

laboratory artifacts. TCE was detected in the sample collected from well GW6I at 5 µg/L. The field duplicate sample collected from well GW6I also contained TCE at 5 µg/L. TCE was not detected in any other samples. Analytical results of TCE analysis of samples collected during round 2 correlate with the analytical results of samples collected during round 1, which also revealed the presence of TCE in the sample from well GW6I (7 µg/L) (TCE was not detected in any other monitoring well samples).

Four groundwater samples were collected from well GW4S during round 2 at successive intervals during the purging of water from the well. The groundwater samples collected from well GW4S contained successively higher concentrations of total-1,2-dichloroethene, ranging from 69 µg/L to 100 µg/L. Total-1,2-dichloroethene was not detected in any of the other groundwater samples collected during round 2 sampling, correlating with round 1 analytical results. Round 1 analytical results revealed the presence of trans-1,2-dichloroethene in the sample collected from well GW4S at 71 µg/L. Trans-1,2-dichloroethene was not detected in the samples collected from any other wells sampled during round 1.

A comparison was made between analytical results of round 1 sampling and analytical results of round 2 sampling. The contaminants detected and the concentrations of the contaminants were similar for both rounds of sampling, indicating that potential sample exposure to headspace gas (as in round 1) did not affect the water samples. Furthermore, the similarity of analytical results of round 1 sampling compared to the analytical results of round 2 sampling indicates that the sample water was representative of the aquifer.

Data obtained through the collection of groundwater samples after successive static well volumes of water were removed from well GW4S indicate that the samples analyzed were representative of the aquifer. (As static water is removed from a well, the evacuated water is replaced with non-stagnant groundwater representative of the aquifer.) If contamination of the water within a well had been caused by the headspace gas being in contact with the water (when collecting a series of samples), the concentrations of contaminants would be expected to be highest in the first sample collected. However, analysis of samples from well GW4S during round 2 indicated that as the static water was

replaced with water representative of the aquifer, the contaminant concentration became greater. In addition to indicating that the contamination is representative of the aquifer, these sample results indicate that some well headspace gas constituents are potentially being introduced to the well by the volatilization of organic compounds from the groundwater within the well.

In addition, WMII's suspicion that the contamination detected in the sample of well GW4S occurred as a result of monitoring well installation is unlikely, based on the following reasons:

- Trans-1,2-dichloroethene was not used in the vicinity of the drill rig or drilling equipment during monitoring well installation;
- The drill rig and drilling equipment were decontaminated as described in 3.3.1; and
- Total-1,2-dichloroethene concentrations were successively higher as static groundwater was replaced with water representative of the aquifer.

4.3.2.3 Round 3 Sampling

Round 3 sampling consisted of the collection of groundwater samples from five FIT-installed monitoring wells and the collection of a duplicate sample and a distilled water field blank sample. Groundwater samples collected during round 3 were analyzed for VOCs only. The CRQLs used were lower than the CRQLs used in the first two rounds of groundwater sampling. Groundwater sample collection was conducted using a submersible pump. The rationale for the choice of sampling locations and the use of low CRQLs for analysis of groundwater samples collected from each well during round 3 included the following factors.

- Well GW6I--to compare previous analytical results of the presence of TCE and to determine whether it was present at a concentration greater than three times the CRQL.

- Wells GW4D and GW6D--to determine whether the contaminants previously detected in samples collected from wells GW4S and GW6I had migrated downward into the lower aquifer.
- Wells GW1S and GW1D--to serve as background samples.

Results. A summary of the analytical results and field measurements of FIT-collected groundwater samples collected during round 3 sampling is presented in Table 4-13. (Laboratory analytical data, including CRQLs of VOCs analyzed for, are provided in Appendix J.)

Discussion. Analysis of samples collected during round 3 revealed the presence of four VOCs. Two of the compounds detected (methylene chloride and acetone) are considered common field or laboratory artifacts. The other two VOCs detected, total-1,2-dichloroethene and TCE, are not common laboratory or field artifacts and are considered to be representative of the groundwater sample. Total-1,2-dichloroethene was detected in the sample collected from well GW6I at an estimated concentration below the CRQL. TCE was detected in the sample from well GW6D and in the duplicate sample from well GW6D at estimated concentrations below the CRQL. TCE was also detected in the sample collected from well GW6I at 5.3 µg/L, a concentration more than three times the CRQL.

The detection of TCE in the sample from well GW6I correlates with the results of samples collected during round 1 and round 2. TCE was detected in samples from well GW6I during round 1 and round 2 at 7 µg/L and 5 µg/L, respectively.

Analysis of the sample from well GW6D and the duplicate sample collected from well GW6D revealed results identifying TCE in the samples.

Table 4-13
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED GROUNDWATER SAMPLES--ROUND 3

Sample Collection Information and Parameters	<u>Sample Number</u>						
	1S	1D	6I	6D	4D	Blank	Duplicate
Sampling Location	GW1S	GW1D	GW6I	GW6D	GW4D	Blank	GW6D
Date	5/19/88	5/19/88	5/19/88	5/19/88	5/19/88	5/19/88	5/19/88
Time	1538	1705	1300	1434	1923	1040	1434
CLP Organic Traffic Report Number	EAA301	EAA302	EAA303	EAA304	EAA305	EAA306	EAA307
Temperature (°C)	5	6	7	13	5	10	13
Specific Conductivity (µmhos/cm)	500	500	500	250	400	0	250
pH	7.43	7.45	7.3	8.07	7.75	6.59	8.07
<u>Compound Detected</u>							
<u>(values in µg/L)</u>							
<u>Volatile Organics</u>							
methylene chloride	--	10	1.1J	4.2	6.1	7.8	4.1
acetone	28JB	--	--	--	--	67JB	--
1,2-dichloroethene (total)†	--	--	1.2J	--	--	--	--
trichloroethene	--	--	5.3	.47J	--	--	.66J

† Groundwater samples collected during round 2 were analyzed for 1,2-dichloroethene (total), as opposed to a distinct analysis for trans-1,2-dichloroethene, which was conducted for groundwater samples collected during round 1.

-- Not detected.

Table 4-13 (Cont.)

COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

Source: Ecology and Environment, Inc. 1989.

5. SUMMARY AND CONCLUSIONS

5.1 INTRODUCTION

Information presented in this section is based on data and information gathered during the site background review, geologic literature review, the geophysical investigation, and the hydrogeologic investigation, which included sampling subsurface soils and groundwater for chemical analysis.

5.2 SUMMARY

5.2.1 Geology and Stratigraphy

- Three distinct units of unconsolidated geologic deposits are present in the vicinity of the site and consist of a depositional sequence of till and outwash deposits associated with the Cahokia alluvium (Holocene) and Wadsworth Till Member of the Wedron Formation.
- A laterally extensive sand and gravel outwash fan associated with Wedron glacio-fluvial deposition (Willman et al. 1975) constitutes the lower aquifer and provides a source of drinking water for the village of Antioch and local residents. The lower aquifer is overlain by the Wadsworth Till.

- The Wadsworth Till varies in approximate thickness from 26 to 60 feet at the site, overlies the lower sand and gravel aquifer, and is laterally extensive.
- An upper sand and gravel unit, possibly representing a Holocene fluvial deposit, is incised into the Wadsworth Till along the southern boundary of the site and constitutes the upper aquifer.

5.2.2 Hydrogeology

- Groundwater flow within the lower aquifer in the vicinity of the site is not influenced by recharge or discharge boundaries, is variable, and is influenced by the pumping of village of Antioch municipal wells.
- Groundwater velocities of the lower aquifer in the vicinity of the site range from approximately 6 ft./year to approximately 35 ft./year.
- The lower aquifer is semi-confined and is heterogeneous.
- Groundwater of the upper aquifer is unconfined and flows from east to west across the southern boundary of the site at velocities ranging from approximately 66 ft./year to approximately 102 ft./year.
- Groundwater of the upper aquifer discharges to Sequoit Creek at the southwestern corner of the site.
- The average horizontal hydraulic conductivity of the upper aquifer is approximately one order of magnitude greater than the average horizontal hydraulic conductivity of the lower aquifer. The average horizontal hydraulic conductivity of the Wadsworth Till is approximately four orders

of magnitude less than the average horizontal hydraulic conductivity of the upper aquifer.

- During the primary pump test, a municipal water supply well screened in the lower aquifer was pumped; drawdown was observed in monitoring wells screened in the lower aquifer and in monitoring wells screened in the overlying Wadsworth Till.

5.2.3 Chemical Results

- PAH compounds were detected in six subsurface soil samples at concentrations below the CRQLs. TAL analytes were not detected at concentrations greater than one order of magnitude above the highest detected concentration of each respective TAL analyte of the background samples.
- Benzene was detected in the groundwater sample collected from well GW7S at 8 µg/L.
- TCE was detected in groundwater samples collected from well GW6I during three rounds of sampling conducted by FIT at 7 µg/L, 5 µg/L, and 5.3 µg/L. TCE was also detected in groundwater samples collected by FIT from well GW6D at .47 µg/L and .66 µg/L.
- Trans-1,2-dichloroethene was detected in a groundwater sample collected from well GW4S at 71 µg/L. A priority pollutants analysis conducted on a leachate sample collected from H.O.D. Landfill on April 11, 1984, also revealed the presence of trans-1,2-dichloroethylene (trans-1,2-dichloroethene) at 45 µg/L (Dames and Moore 1985).
- Total-1,2-dichloroethene was detected at concentrations ranging from 69 µg/L to 100 µg/L in each of a series of four groundwater samples collected by FIT from well GW4S

after successive volumes of well water had been purged from the well. Total-1,2-dichloroethene was also detected in a groundwater sample collected by FIT from well GW6I at an estimated concentration of 1.2 µg/L.

- The estimated concentrations of zinc detected in groundwater samples collected from FIT-installed monitoring wells ranged from 24 µg/L to 61 µg/L. Zinc was detected in groundwater samples collected from all WMII monitoring wells and ranged from an estimated concentration of 52 µg/L to an estimated concentration of 3,340 µg/L.
- Within the range of concentrations that zinc was detected in FIT-collected drinking water samples, some samples contained comparatively high concentrations; however no samples contained zinc at concentrations above the secondary MCL.

5.3 CONCLUSIONS

The H.O.D. Landfill site partially overlies an upper sand and gravel deposit that is separated from a lower sand and gravel deposit by a leaky till unit (Wadsworth Till). Both sand and gravel units are water bearing; however, only the lower unit is known to be used as a source of drinking water. The thinnest identified area of Wadsworth Till in the vicinity of the site is located near the southern boundary of the landfill and is directly overlain by the upper sand and gravel aquifer. Pump test results indicate that the lower aquifer is partially recharged by the downward movement of groundwater through the Wadsworth Till.

TCE, trans-1,2-dichloroethene, and total-1,2-dichloroethene have been detected in groundwater at the H.O.D. Landfill site. Trans-1,2-dichloroethene and total-1,2-dichloroethene have contaminated groundwater in the upper aquifer. TCE has contaminated groundwater in the Wadsworth Till and in the lower aquifer. A potential exists for contaminated groundwater to migrate from the landfill to the village of

Antioch municipal wells (particularly municipal well 4 because of its proximity to the landfill).

Prior to the ESI, WMII monitoring well G103 was replaced with monitoring well R103 after analysis of a groundwater sample collected from G103 revealed the presence of a high concentration of zinc. During the ESI, FIT did not verify the presence of zinc contamination at WMII monitoring well R103. Although elevated concentrations of zinc were detected in groundwater samples collected from other WMII monitoring wells at the site, WMII's claim that zinc contamination of groundwater samples was caused by deteriorating galvanized steel protector pipes could not be refuted based on information gathered during the ESI.

Contaminants detected in the subsurface soil samples cannot be conclusively attributed to the site, based on the distribution pattern of TCL compounds and TAL analytes detected at the locations sampled.

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